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NOTES AND COMMENTS.

Steel Outputs.

The question of steel production has such an important bearing on the prosecution of the war, that readers may be interested to review the relative positions of different nations in this connection. In the following table the statistics of steel production for the years 1913, 1914 and 1915 (as far as they are available) are grouped together so as to show the total output in the British Empire, the output of our Allies, the output of the Central Powers, and that of the United States. It will

TABLE I.—*Summary of Steel Production.*

	1913.	1914.	1915.
	Tons.	Tons.	Tons.
United Kingdom	7,663,876	7,835,113	8,550,015
Canada	1,042,503	694,447	911,013
India	—	66 603	108,474
Australia	—	24,420	99,000
Total..	8,706,379	8,620,583	9,663,502
Belgium	2,466,630	1,200,000*	—
France	4,635,166	—	—
Italy	933,500	911,000	—
Russia	4,837,000	4,732,000	4,018,000
Total..	12,872,296	5,643,000	4,018,000
Combined totals ..	21,578,675	15,463,583	13,681,502
United States	32,321 618	24,206,276	32,871,036
Germany	18,958,819	14,973,106	13,258,054
Austria-Hungary	2,625,879	2,160,239	2,674,197
Total..	21,584,698	17,133.345	15,932,251

* Estimate for first half of 1914.

be seen that, roughly speaking, the enemy production is about equal to that of our own and our Allies combined. The production within the British Empire is increasing, and doubtless the figures for 1916 will show a still further improvement in our position. The output of the United States is about

TABLE II.—*Production of Steel Castings in the United States.*

	1913.	1914.	1915.
	Tons.	Tons.	Tons.
Open-hearth basic	460,161	334,144	333,103
" " acid	450,055	270,173	402,229
Total open-hearth	910,216	604,317	735,332
Bessemer	80,506	65,882	92,476
Crucible	17,571	11,186	14,756
Electric	9,207	8,551	23,064
Miscellaneous	3,244	3,310	1,196
Total steel castings ..	1,020,744	693,246	866,824

equal to the rest of the world combined. The advantage which we possess through our friendship and trade with them is therefore very obvious. The figures are taken from a report by Mr. G. C. Lloyd (Supervisor of the Statistical Bureau of the Iron, Steel and Allied Trades Federation).

Light Steel Castings and Foreign Competition.

During recent years a source of irritation to British steelfounders has been the fact that in the light steel castings trade Belgian foundries were able to undercut in British markets, and this with castings made from British hematite iron imported into Belgium. The position was really incongruous, particularly in view of the freight cost involved in shipping the materials and castings, and many suggestions as to the cause were put forward by different people. Mr. E. F. Lange, in a paper before the Manchester Association of Engineers recently, stated that as a result of careful study of the Belgian steel-casting industry, by personal observation and inquiries in that country itself, he had come to the following conclusions as regards the causes that led to its success.

(1) The excellent organisation and equipment of the steel foundries.

(2) The suitability of the small converter for making small and medium weight castings, as shown by the fact that the output of steel castings in Belgium has quadrupled itself in the last 12 years.

(3) The advantage of no artificial restraint of the production on the part of the trade unions, *i.e.*, the advantage of working piecework instead of day work.

(4) The fact that small converter castings require smaller casting heads and runners than with the open-hearth process.

(5) The castings require less annealing.

(6) The Belgians have an abundance of cheap natural moulding sand, particularly suitable for the small converter process.

The first conclusion has doubtless much support in fact; while the second, with respect to the suitability of the small converter, will be supported by the opinion of a considerable number of men in this country. Contention has often been raised regarding the relative value of converters and other types of furnaces, but not on the technical details of output per hour or per ton of fuel alone can the matter be settled. There are so many factors, such as convenience of operation, size and cost of installation, auxiliary plant, and so forth, which affect the final question of suitability, that the matter may be said to be still undecided. Possibly the third conclusion arrived at by Mr. Lange has had a bearing on Belgium's success; but piecework cannot be accepted as a system without serious drawbacks. Moreover, the poor results often obtained by day-work are often inseparably connected with bad organisation.

The claim that Bessemer castings require less annealing, too, must not be accepted at its face value. For some classes of work which do not have to meet severe requirements, converter castings which have been normalised (which is really the correct term for most of the so-called light annealing to which such work is subjected) serve very well; but when first-class light castings are in question such material is unreliable, owing to its low resistance to shock. The final conclusion, i.e., in regard to moulding sand, is to a great extent justified; but prejudice is a serious fault on the part of many of our founders, in that it often confines them to unsuitable sands when far better ones are to be had. There is no reason why British founders should not do what Belgian founders have done, provided they are willing to set about the work in a businesslike manner, equip their plants for the work, specialise, and discard any old ideas of material and method which may prove to hamper success.

Heredity and Pig-Iron.

Again we have to the fore in foundry circles discussions on what might be termed the effect of heredity and environment on the character of iron —in other words, the effect of raw materials and blast-furnace processes, and also of conditions during the passage from pig-iron to castings. In the biological world authorities are still at variance as to the relative influences respectively of heredity and environment, but all are more or less agreed that both are influential factors in the final development of any organism. In the metallurgical world, however, there has been too often a tendency to take the stand that one or other influence has predominant control. In seeking an explanation for the varying characteristics of different irons the enthusiast will sometimes attach himself with a touching devotion to one or other of the suggested influences, and credit it with almost omnipotence in the control of such qualities as strength and texture of a casting. Experience, however, has proved that the influences at work to determine the characteristics of an iron are not unifold but manifold, and that while a theory involving control by, say, the quantity present of one particular element may appear over a large range of experiments to give absolute results, inevitably someone will bring forward reliable data gathered under slightly different conditions that appear to discount the first. A broad examination of both aspects of the question generally shows that each has in it essential truths, but not the whole truth. Take, for example, the question of carbon in cast iron. It is well appreciated that the chief determining factor in the strength and hardness of an iron is the carbon content and the condition in which that carbon exists. This has led to a study of the influences affecting carbon condition, and the effect of other constituents thereon. Turner's work on the influence of silicon stands prominent as one of the most important contributions of its kind. The effects of other constituents, of casting temperatures, rates of cooling, and conditions of melting have also had extensive consideration; but, unfortunately, the results obtained by such experiments, reliable though they may be, have been taken individually too often, and accepted by founders without reference to other influences.

With any given iron the effect of any one of the foreging influences may be determined, and the characteristics of the iron modified with considerable reliability. But an initially different iron may respond to a very different degree, or even fail to respond to the same influence. Most practical men will affirm, and quite rightly, that certain irons retain their hereditary characteristics, i.e., those with which they were endowed at birth in the blast furnace. Later influences may more or less modify them—in fact, almost inevitably do—and may ultimately quite subordinate them; but in the ordinary process of remelting and casting the characteristics are largely retained.

The subject chiefly resolves itself into the question of complete solubility of the constituents when the iron is melted in the cupola. Most of the existing theories regarding cast iron assume that when metal leaves the cupola all its constituents are completely dissolved in the iron and lose their identity as crystals; but that has of late been frequently called into question. Fortunately more attention is being paid to the subject by all concerned, and a discussion may, therefore, be anticipated.

Cast Iron.*

By E. Adamson.

Of recent years it can be said that the metallurgical world has been divided into two schools: that of the chemist and that of the physicist; or, perhaps more correctly, analytical chemistry and physical chemistry. The analyst makes an emphatic statement that all the physical properties of cast iron and steel are due to the direct influence of chemical composition; the physicist states that whilst chemical composition undoubtedly has an influence on the properties of iron, the primary influence is due to properties produced in the course of manufacture and treatment, and possibly even influenced by the physical properties of the raw materials. Only after that—or basis principle—are the physical or mechanical properties of iron modified by chemical composition, although the same tests can be obtained on more or less widely different analyses.

Looked at in its true perspective, such a statement casts no reflection upon the ability or reputation of many eminent investigators who have contributed to the present knowledge of the metallurgical world. No one person ever had, or ever will have, *all* the truth; and for anyone to claim a superior knowledge in any direction is only riding sooner or later for a fall. Every investigator has contributed something to the knowledge of science, for the publication of even a negative result may lead others to the positive.

Going through the early publications of the Iron and Steel Institute, some very curious opinions are expressed. For instance, in 1870 the late Frederick Siemens gave a paper denying the statement by Dr. Lardner that cast iron melts at 17,977 deg. F., and iron—for there was no steel in those days—at 21,000 deg. F. We know now definitely that pure iron melts at 1,500 deg. C.

It is possible that the idea of the influence of chemical analysis on the physical properties of cast iron was primarily due to a paper published 30 years ago. The materials apparently used in making the test bars for this investigation were pig-iron and wrought iron, which were melted together *in crucibles* in different proportions to produce varying silicon contents. Out of that paper probably sprang the theory that the percentage of silicon controls not only the grade or fracture of pig-iron, but also largely the percentage of total carbon and the ratio of combined carbon to graphite; and, in fact, primarily controls the physical properties or tests, as is instanced in Table 1, in which it is stated that the highest tensile

Table 1.

	Silicon.
Maximum hardness	under 0·80 per cent
Crushing strength	about 0.80 ,,
Modulus of elasticity	,, 1.00 ,,
Density, in mass	,, 1.00 ,,
Combined crushing and tensile strength: transverse strength	,, 1.40 ,,
Tensile strength	,, 1.80
Softness and working qualities	,, 2.50
Lowest combined carbon	under 5.00 ,,

is obtained with silicon 1.80 per cent; the highest combined crushing, tensile and transverse strength, silicon 1.40 per cent.; the highest crushing, silicon 0.80 per cent.; the greatest density, silicon about 1.00 per cent., etc.; but it is only necessary to say that as 1 per cent. silicon would probably give grey iron, the greatest density would be in white iron containing probably half that percentage of silicon.

Examining the table from which these results were obtained, the total carbon of all the test bars is a little under or a little over 2.00 per cent. Such a total carbon cannot be found in any pig-iron produced in the blast furnace, and therefore any deductions drawn from this table are only applicable to tests made *with similar materials under precisely similar conditions*, and are not applicable to commercial pig-irons, particularly of modern manufacture, with nearly double these total carbons. With pig-iron and steel melted together in the cupola to produce a theoretical total carbon of 2.00 per cent., the metal in the ladle would be found to have a minimum total carbon of 3.00 per cent., and one of my friends informs me that he melted all steel in the cupola and obtained a total carbon of 4.00 per cent.

It may here be stated, however, that these remarks do not in any way depreciate the high value of Turner's classic researches on the influence of varying silicon on cast iron; for their value has for many years been well appreciated. But it is necessary to bear in mind the logical deductions to be made from Turner's work, and not attempt to formulate general conclusions to cover all conditions which may result in varying silicon contents in iron.

It would be most unwise to say that the presence of silicon has absolutely nothing whatever to do with whether pig-iron, and consequently castings, are grey, mottled, or white—hence, soft or hard—but the points it is wished to emphasise are:—

(1) Silicon content does not *control* the fracture of the pig-iron;

(2) Silicon content does not *control* the percentage of total carbon in pig-iron;

(3) Silicon content does not *control* combined carbon and its ratio to graphite;

(4) Silicon content does not *control* the mechanical tests of pig-iron—i.e., tensile, transverse, and deflection, all other elements being constant.

To prove the first point, the analyses shown in Table 2 are of No. 1 hematite pig-irons, with varying contents of silicon from 0.35 per cent. to 5.85

Table 2.

No.	Fracture.	T.C.	G.C.	C.C	Si.	S.	P.	Mn.	Remarks.
1	No. 1 ..	4.23	3.62	0.61	0.67	0.026	0.040	0.40	—
2	No. 1 ..	3.65	3.08	0.57	1.46	0.040	0.030	0.72	—
3	No. 1 ..	3.76	3.20	0.56	2.14	0.038	0.031	0.78	—
4	No. 1 ..	3.23	2.83	0.40	3.93	0.030	0.040	1.30	Very large flakes.
5	No. 1 open	3.67	3.50	0.17	4.98	0.034	0.041	1.34	Same cast
	No. 1 close	3.67	3.49	0.18	4.63	0.034	0.041	1.34	Open & close No. 1 fractures
6	No 1 ..	3.14	3.02	0.12	5.85	0.033	0.043	1.00	—
7	No. 1 close	3.28	2.22	1.06	0.35	0.026	0.020	0.07	Supplied by Sir R. A. Hadfield

per cent., and the fracture showed the iron with silicon 0.35 per cent. to be perfectly grey. Incidentally, it will be interesting to note that the total carbon with silicon 0.35 per cent. is practically the same as with silicon 5.85 per cent., and

* Paper read before the Scottish Branch of the British Foundrymen's Association.

if the total carbons of the pig-irons in this table are compared, they do not vary in ratio with silicon contents.

Table 3 shows a series with varying analyses and varying fractures. No. 1 in this table is admittedly an alloy—i.e., white pig-iron with additions of

Table 3.

No.	Fracture.	T.C.	Si.	S.	P.	Mn.
1	White alloy	4.60	0.79	0.018	0.016	1.26
2	Grey No. 1	4.23	0.67	0.026	0.040	1.40
3	White	4.20	0.20	0.020	0.020	trace
4	Grey No. 1	3.50	2.00	0.030	1.560	0.30
5	Grey No. 1	3.28	0.35	0.026	0.020	0.07
6	Grey close	2.95	0.95	0.065	0.980	1.65
7	Grey	2.90	4.83	0.010	1.050	0.61
8	Grey close	2.60	1.70	0.030	0.080	0.08

silicon and manganese melted in the crucible, but all the other samples are virgin (or commercial) pig-irons, and it is with these that the ironfounder has to deal.

The same three tables prove point (2), that the silicon content—as already shown—does not *control* the percentage of total carbon. Table 4 shows a pig-iron direct from the blast furnace, with no silicon, and a lower total carbon than the theoretical. Table 5 shows a silicon 1.89 per cent. and total carbon 2.98 per cent., which, strangely, is white pig-iron. Admittedly a freak iron, but it is from the freaks we learn the truth. Table 6 is from Foster's experiments in melting steel in contact with charcoal; he gets total carbon 4.66 per cent. with *silicon 0.098 per cent.*, which was grey in the fracture, although thin in section and "chilled" in cooling. Table 7 is from Percy's

Table 4.

	Per cent.
Graphitic carbon ..	trace
Combined carbon ..	3.87
Silicon	nil
Sulphur	0.074
Phosphorus ..	0.037
Manganese	0.30

Table 5.

	Per cent.
Combined carbon ..	2.98
Graphitic carbon ..	traces
Silicon ..	1.89
Sulphur	0.27
Phosphorus ..	1.62
Manganese	0.29

Table 6.

	Per cent.
Total carbon ..	4.665
Graphite	2.136
Soluble carbon ..	2.529
Silicon	0.098

Table 7.

	Per cent
Iron	95.66
Graphite	4.56
	100.22

book, published in 1864, giving an example of pure iron, and carbon *which was all graphite*. These slides also prove that it is not necessary to have silicon present to precipitate graphite, but there is some other influence outside of silicon.

The next Table, No. 8, shows that silicon does not control the percentage of combined carbon, for

Table 8.

A.		B.	
C.C.	Si.	C.C.	Si.
Trace	3.12	0.54	1.81
0.25	2.90	0.57	3.11
0.35	1.23	0.60	2.36
0.35	2.52	0.60	2.51
0.36	1.52	0.60	3.05
0.44	2.23	0.62	3.19
0.50	1.84	0.62	3.50
0.51	1.75	0.83	2.33
0.52	1.65	—	—
0.54	1.31	—	—
0.58	2.19	—	—
0.66	1.82	—	—
0.70	0.98	—	—

with silicon 3.00 per cent. to 3.50 per cent. there is combined carbon from trace up to 0.60 per cent., the former being from test bars, which should have been harder on the re-melting; and the second lot with combined carbon 0.60 per cent. is from pig-iron. "A" is from a series of test bars, and "B" from virgin pig-irons normally cooled. Table 9

Table 9.

	Per cent.	Per cent.
Total carbon	3.28	3.25 to 3.50
Graphitic carbon	2.22	nil
Combined carbon	1.06	3.25 to 3.50
Silicon	0.35	0.32
Sulphur	0.026	0.049
Phosphorus	0.02	0.04
Manganese	0·07	0·135
Fracture	grey	white

gives No. 1 and also white iron of the same silicon contents; the grey iron is from the blast furnace, and the white a refined malleable pig-iron.

Table 10, which is taken from an early edition

Table 10.

A. Pig ..	Si. 1.25	S. 0.035
Casting ..	Si. 1.15	S. 0.070
B. Pig ..	Si. 2.86	S. 0.040
Casting ..	Si. 2.67	S. 0.046

No.	Transverse.	Deflection.		Strength in lbs.	
		A.	B.	A.	B.
1	½×1½	0.29	0.35	110	164
2	½×1½	0.25	0.03	320	344
3	½×1½	0.21	0.24	550	530
4	½×1½	0.18	0.18	860	920
5	½×1½	0.15	0.14	1260	1208
6	½×1½	0.14	0.12	1600	1640
7	½×1½	0.12	0.11	2240	2320
8	1 ×1½	0.10	0.10	2900	2860
9	1½×1½	0.08	0.10	3600	3500

of West's book on "The Metallurgy of Cast Iron," gives practically identical transverse tests from widely different silicon contents; and Table 11

Table 11.

Highest tensiles. Variable element	Si.	S.	P.	G.C.	C.C.	Lbs. per sq. in.
Combined carbon ..	1.29	0.053	0.179	2.84	0.92	35,950
Silicon	1.27	0.07	0.178	2.98	0.85	29,050
Sulphur	1.23	0.141	0.202	2.96	0.97	35,650
Phosphorus	1.06	0.078	0.247	2.97	0.85	30,300

Highest transverse—Bars 2 in.×1 in.×2 ft. centres.

Variable Element	Si.	S.	P.	G.C.	C.C.	Lbs.	Deflection.
Combined carbon	1.21	0.061	0.174	2.95	0.93	3,100	19
Silicon	1.07	0.077	0.183	3.07	0.78	2,950	17
Sulphur ..	1.19	0.072	0.197	3.07	0.80	3,050	18
Phosphorus ..	1.06	0.078	0.247	2.96	0.85	2,850	18

Highest drop test—Bars 1 in.×1 in.×12 in centre.

Variable element.	Si.	S.	P.	G.C.	C.C.	Drop test
Silicon	1.01	0.077	0.183	3.07	0.77	10 blows
Sulphur	1.19	0.072	0.197	3.07	0.80	11 "
Phosphorus ..	1.01	0.075	0.150	2.93	0.83	10 "

SUMMARY.

Element.	Highest.			
	Tensile.	Transverse.	Deflection.	Drop test.
Combined carbon..	0.92	0.93	0.93	—
Silicon	1.27	1.01	1.01	1.01
Sulphur	0.141	0.073	0.073	0.073
Phosphorus ..	0.247	0.247	0.247	0.150

shows the highest tests—tensile, transverse, etc.—with one varying element in a series of numerous tests, and it will be noted that there is no difference worth speaking of in the complete analysis of the highest test obtained in each series of tests with each element varying, which is hardly in keeping with silicon control.

It may be said that Americans and others have graded their pig-iron by analysis, which practically amounts to grading by silicon contents; but not

only have their specifications been modified from time to time, but several of the leading iron-founders of the United States have acknowledged privately that whilst they purchase pig-iron by analysis they do not rely upon this entirely, particularly for special work. It must, of course, be remembered that in America pigs are "machine" cast, i.e., cast into chills, and, therefore, the fracture does not represent the true fracture of the pig if cast in sand. Under such conditions, grading by analysis is necessary, but castings of machines coming into this country from America are not up to the standard of our foundries, and they do not prove the efficacy of working on the basis of analysis—in fact, many of these castings would be scrapped in British foundries.

As an illustration of what is meant by the author, are given in Fig. 1, fractures taken from the same pig of iron, i.e., a Scotch brand. It will be seen that one is open and the other is close. The reason of the difference in these two fractures from the same pig of iron is simply that the closer fracture is what is commonly known as "chilled," and every practical ironfounder knows what "chilling" means.

In parentheses it may be said here, that for the great bulk of iron-foundry work there is a wide range of possible analyses which can be used with safety, but when it comes to the use of iron where regular tests are required, or where the castings have to be particularly sound, it would not do to use iron simply by analysis, which, in fact, in the past has practically amounted to use by silicon contents.

Table 12 relates to refined pig-irons—one spotted white, the other grey—from the same

Table 12.

	T.C.	G.C.	C.C.
	Per cent.	Per cent.	Per cent.
Proper fracture—s.w.	3.30	0.10	3.20
Sheeted pig—grey	3.30	2.58	0.72

cast, and consequently of the same analysis. The reason of the difference in these two fractures is that the pig-iron as it lay in the beds was originally a spotted white fracture, but owing to one of the beds breaking away and sheeting the next lower bed, which was left to cool until the following morning, the fracture of the "sheeted" pig became completely grey and open. We have exactly the same condition existing in the annealing process of malleable cast iron, where a perfectly white fracture at a comparatively low temperature, and very much lower than the foregoing, or of the melting point of cast iron, turns perfectly grey, particularly in what are known as "black heart" malleable castings, which are annealed at a low temperature and have a high percentage of total carbon as free carbon in the centre. It is, of course, well known that malleable castings are white before annealing.

Table 13 shows the carbon and silicon analyses

Table 13.

	Keeping metal molten for		
	(1) 3 hours.	(2) 4½ hours.	(3) 5½ hours.
	Per cent.	Per cent.	Per cent.
Total carbon	4.03	4.81	4.73
Graphitic carbon separation ..	3.00	3.84	4.03
Combined carbon (by difference)	1.03	0.97	0.70
Silicon	0.024	0.04	0.07
Other impurities	—	—	0.005

of commercially pure iron melted in the presence of carbon, and retained in the molten condition for a number of hours. From this it will be seen that not only does the total carbon increase the longer the iron is kept molten, but the ratio of combined carbon to graphite is also altered, purely as a condition of temperature and time.

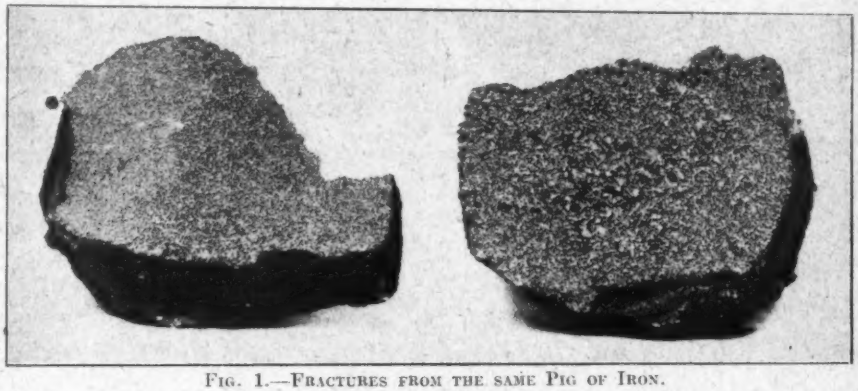


Fig. 1.—Fractures from the same Pig of Iron.

That may be said to represent what takes place inside the blast furnace, and it also explains *in principle* the reason of the many apparently peculiar analyses shown in the accompanying tables. It would be absurd to argue that the presence of silicon, which is practically a trace in these tests of Saniter's, had any influence whatever on the carbon and its condition. What had an influence was temperature in the blast furnace and time there also. It will also be seen that the separation of graphite takes place even in molten iron; but more of this later.

This phrase "temperature and time" has been variously translated—for instance, into the word "mass," meaning slow cooling; and whilst it is well known that even white iron will be grey in the centre if the casting is sufficiently thick and slowly cooled, the term "temperature and time" is not intended to apply to "mass," but to the conditions existing inside the blast furnace during the time when the iron is being manufactured. In the use of this phrase all other conditions, such as on the pig beds and in the foundry, have been taken as ordinary practice.

To put this into a nutshell, cold-blast pig-iron has considerably greater *physical* properties than hot blast. It may be possible to get the same tensile and transverse tests from refined pig-iron, but whilst grey cold-blast iron will not lose its mechanical properties, rather improve them on several re-meltings, if the "refined" iron is melted in the cupola, run into pigs, and then used, the test goes right back to its original figure. Further, castings made from cold-blast iron will stand fire and fatigue for a very much longer period of time than those made from hot blast. From this it would, therefore, appear quite evident that the process of manufacture of pig-iron plays a leading and primary part in its *physical* properties—using that term in its widest meaning—and also plays a predominant part in the total carbon and the ratio of combined carbon to graphite, and probably accounts at least to some extent for one brand of pig-iron from the same ores being better than another.

The percentage and the *condition* of carbon decides whether the iron is open or close in the fracture, and leaving out extremely thin castings which are chilled in the cooling, it can be taken as a principle that a No. 1 iron does not become close when it is melted once and cast into a section of, say, the same thickness as the original pig, whilst a *true* close pig-iron of identical silicon, sulphur, phosphorus and manganese does not become open when it is melted in the cupola and cast into a section of its original thickness. In these two inherent principles lies the explanation of why some castings are extremely porous and others are close grained. There are some close-grained irons—"chilled" fractures—which when melted and cast into the same section, would be more open than the original fracture.

Next with regard to the influence of silicon. It is an undoubted fact that, taking a given iron *under exactly the same conditions* of melting, pouring and cooling, the higher the silicon the softer the iron within limits, and these limits apply in general principles to all the fractures of pig-iron between white and mottled on the one hand, and "glazy" pig on the other; but it has been my experience that it is possible to get practically the same tensile and transverse tests from 1.00 per cent. silicon and from 3.00 per cent.; hence it will be seen how it is possible to meet the demands of the machine shop on the one hand, and the demands of the engineer, who asks for solid castings, on the other.

Sulphur.

Next with regard to sulphur. There seems to be a rooted objection to irons containing, say, 0.10 per cent. sulphur, probably because of the sulphur specifications issued by the Americans, but when we come to a practical experience of the use of irons somewhat high in sulphur we have the following facts facing us:—

Finspong iron, a Swedish charcoal cold-blast, which usually contained sulphur 0.15 per cent., was used in the old days for making cannon. Evidently, therefore, it was the strongest iron obtainable. Johnson's tests with varying sulphur contents (shown in Table 11) gave the highest tensile result with sulphur 0.141 per cent., and it is well-known that cold-blast irons, which usually contain higher sulphur than the hot-blast irons, give very much higher mechanical tests, and have a greater resistance to fire and fatigue, both of which are as important as mechanical tests.

The writer of one Paper which was given before the Cleveland Engineers made a statement that the first iron tapped from the cupola was hard because it contained higher sulphur than the following taps. To test this statement I sent to the laboratory a series of samples from the first, and about third, fifth, seventh and ninth tons, which were tapped from the cupola running on the same burden, and the sulphur from the first tap was certainly higher than from the following taps, but the difference between the first—which was 0.091 per cent.—and the last and lowest of the others, 0.08 per cent., was, certainly, to my mind, not sufficient to make a difference in the hardness of the iron. But what is undoubtedly the cause of the difference in the hardness of the first tap is that the first iron melted in the cupola falling on to a cold bottom, is consequently "chilled," with the result that it is harder than the following casts, which fact has certainly nothing to do with chemical analysis.

This opinion about sulphur undoubtedly originally arises from Fairbairn's tests, which seems to have started the theory that 0.50 per cent. sulphur turns grey iron white, and that therefore sulphur must be harmful. Table No. 14 will show the absurdity of such a statement when applied generally, yet the statement is correct, *providing* a grey iron is taken of such a hardness which will be very near to mottled—say a No. 5 iron; then if sulphur is added to that fracture it will undoubtedly turn it white; but if sulphur is added to an open No. 1 iron it would take a few per cents., not tenths per cent., of sulphur to turn that iron white.

Table 14.

	No. 1	Mottled.
Si	3.00	4.26
S	0·50	0.46
Mn.	0.25	0.70
C.C.	0.60	1.80
G.C.	2.90 approximate	1.90

It is not intended by this statement to advocate the regular use of pig-iron high in sulphur, but the point it is wished to emphasise is, if anything goes wrong with the casting, it does not follow that sulphur of, say, 0.10 per cent., or even up to 0.15 per cent., is the *cause* of the bad casting.

Phosphorus.

It is usually assumed that good tests cannot be obtained with phosphorus above 0.75 per cent. This is purely a fallacy, for it is quite possible to obtain good tests for the most stringent surveys from a phosphorus content of 1.00 per cent. to 1.25 per cent., as will be seen in Table 15. This shows a transverse test of 5 cwts. above requirements on a test bar 1 in. by 1 in. by 12 in. centres, and an increase in the transverse test per sq. in. as the bars are reduced in size from 1 in. square to ¼ in. square—the ¼ in. square giving 34 cwts. transverse per sq. in., which is the result of rapid cooling, thus closening the grain of the iron With phosphorus 1.00 per cent. to 1.25 per cent., the following results have regularly been obtained:—Transverse test on 2-in. by 1-in. bar with 3-ft. centres—32 to 33 cwts., with a regular deflection of 0.65 in. and up to 0.80 in. This would not be specially high for so-called strong iron, but it is high when the silicon is 3.00 per cent. Further deflections with a similar phosphorus and over 1.00 per cent. silicon gave 22 to 24 cwts. on a 1-in. by 1-in. bar with 12-in. centres; also tensiles of 11 to 14 tons.

Phosphorus possibly segregates to the last place of cooling in the cooling of pig-iron more than any

other element, and particularly where castings are thick and thin, the influence of phosphorus will make itself felt in the thick parts, but providing the phosphorus is evenly distributed, as in close-grained irons, it is not so dangerous as some people think.

Whilst under exactly the same *laboratory* tests, as shown in Table 16, phosphorus, *per se*, appears to lower the test results of iron with increase of phosphorus, the point it is wished to make here is that it is possible to have good physical properties in pig-iron as disclosed by fracture which enables a fairly high percentage of phosphorus to be used with safety. Table 17 shows the rate of cooling in fall of degrees per minute with increasing phosphorus, and somewhat goes against the usually accepted theory that the higher the phosphorus the longer the " life " of molten metal. The chemical influence of phosphorus in blast-furnace practice seems to be the lowering of the total carbon. This is a matter of mathematical calculation, for the higher the phosphorus the lower the cubic capacity of the iron—pure iron—to take the carbon; also phosphorus slightly decreases the combined carbon and its ratio to graphite. The presence of phosphorus undoubtedly tends to give a " thinner " or more easily running iron.

Many of the above statements on sulphur and phosphorus are now in very good company, for whilst this Paper was in draft, on the first day of the last Iron and Steel Institute meeting in London in September last, Dr. J. E. Stead, of Middlesbrough, in his " unorthodox " Paper stated in regard to steel that " sulphur and phosphorus were not such enemies as generally supposed, but could be used as friends." A similar statement was made by me in regard to cast-iron several years ago, my object always having been to get a better understanding between the ironmaster and the ironfounder, so that the ironfounder would not make impossible demands upon the ironmaster.

Table 15.—*Tests.*

Size of bar. Nominal.	Size of bar. Actual.	No.	Deflection.	Load-Cwt.	Cwts. per sq. in.	Mean.
	Width Depth.					
1 in. sq.	1.02×0.98	1	½	21½	22.08	24.07
	1.02×0.98	2	½	23½	24.05	
	1.00×0.98	3	5/32	25½	26.10	
¾ in. sq	0.77×0.76	1	5/32	11½	26.42	26.33
	0.76×0.76	2	½ bare	11½ full	26.77	
	0.78×0.76	3	½	11½	25.8	
½ in. sq.	0.54×0.52	1	½ bare	4½	28.68	28.97
	0.54×0.52	2	½	4½ bare	29.11	
	0.54×0.52	3	½	4½	29.11	
¼ in. bare	0.28×0.26	1	¼	¼	36.32	34.12
	0.28×0.26	2	¼	¼	33.02	
	0.28×0.26	3	½	¼ full	33.02	

Manganese.

Manganese appears to clean the iron, i.e., an iron of otherwise the same analysis and fracture, but containing higher manganese, would be cleaner and thinner running metal than one containing practically no manganese, but it does not always follow as an invariable rule that iron containing high manganese is a clean iron, for it is quite possible to have a dirty iron containing high manganese. Table 16 shows that manganese 1.00 per cent. to 1.25 per cent. appears to give good tests, but above this the tests fall away, and this is the general practical experience. Table 17 would suggest that manganese retards the rate of cooling in the fall of degrees per minute. It thus gives the iron time to sink and become more solid, but, of course, this must be taken within reasonable working limits, and refers to " clean " irons.

The theory that silicon controls carbon and its condition in pig-iron having been disproved, one

Table 16.

No.	Analysis. Total carbon.	Graphitic carbon.	Combined carbon.	Silicon.	Sulphur.	Phosphorus.	Manganese.	Chill tests. Temp. degrees.	Depth of chill Ins.	Transverse. 2 in.×1 in.×3 ft. Cwts.	Deflection Ins.	Tensile tests. Tons per sq. in.
1	3.30	2.32	0.88	0.740	0.030	0.629	0.970	1215	½	29.92 (u)	0 50	8.76
								1187	½	28.54 (d)	0.60	
2	3.33	2.58	0.75	1.166	0.032	0.538	0.800	1222	½	37.40 (u)	0.45	15.79
								1187	½	41.70 (d)	0.50	
3	3.28	2.61	0.67	1.400	0.029	0.557	0.760	1240	½ f	37.66 (u)	0.50	15 86
								1187	½ b	37.78 (d)	0.50	
4	3.30	2.42	0.88	0.910	0.038	0.303	0.770	1258	1	48 90 (u)	0.55	
								1236	½	35.42 (d)	0.35	
5	3.35	2.50	0.85	1.050	0.048	0.690	0.500	1258	½	43.64 (u)	0.50	
								1160	½	33.50 (d)	0.35	
6	3.30	2.54	0.76	0.980	0.054	1.075	0.620	1258	½	40.96 (u)	0.30	
								1208	½	28.26 (d)	0.35	
7	3.32	2.58	0.74	1.080	0.042	0.570	0.613	1208	½	43.70 (u)	0.75	
								1215	½	40.40 (d)	0.71	
8	3.43	2.53	0.90	1.070	0.042	0 490	1.170	1282	1½	47.16 (u)	0.50	
								1194	1	34.20 (d)	0 31	
9	3.33	1.68	1.65	1.060	0.042	0.550	1.600	1274	1½	28.48 (u)	0.26	
								1229	1½	24.80 (d)	0.27	
10	3.34	1.24	2.10	1.050	0.043	0.490	3.250	1266	1½	27.02 (u)	0.22	
								1201	1	26.40 (d)	0.24	

(u) Tested with " fin " up—i.e., in compression. (d) Tested with " fin " down—i.e., in extension.

may reasonably ask for a constructive theory. It is this: The conditions existing in the blast furnace at the time of its manufacture are the controlling influences in producing fractures of pig-iron, and fracture represents the physical properties of cast iron, which may be slightly modified by the final chemical analysis.

Cupola Influences.

So much concerning pig-iron, but there is also the cupola influence upon the fracture and carbon. For instance, one may charge a theoretical low percentage of total carbon on the cupola, but may get a totally different result—i.e., much higher—at the spout, or otherwise in the ladle. The worst instance of this in my experience was when the

Table 17.

No.	Variable element.	Casting temperature of each chill. Degrees.	Difference in degrees.	Time in minutes between each chill.	Rate of cooling in degrees per minute.
1	Si. 0·740	1215 1187	28	2.0	14.00
2	Si. 1.166	1222 1187	35	2.25	15.55
3	Si. 1.400	1240 1187	53	2.0	26.50
4	P. 0.303	1258 1236	22	2.41	9.12
5	P. 0.690	1258 1160	98	3.50	28.00
6	P. 1.075	1258 1208	50	2.0	25.00
7	Mn. 0.613	1298 1215	83	2.66	31.20
8	Mn 1.170	1282 1194	88	3.66	24.04
9	Mn. 1.600	1274 1229	45	2.50	18.00
10	Mn. 3.250	1266 1201	65	3.66	17.76

cupola burden had a theoretical total carbon of 3.25 per cent., or thereby, and the casting contained about 4.50 per cent., which, as the total carbon in the pig-iron was constant, worked out that the scrap must have had over 9.00 per cent.—which was most improbable.

The reason was simple enough when investigated. First, the bed coke was about double the quantity necessary. Next, a large proportion of the coke

Table 18.

	A.	B.
Total carbon	4.20 per cent.	3.90 per cent.
Graphitic carbon	3.62 ,,	Trace
Combined carbon	0.58 ,,	3 90 per cent
Silicon	1.02 ,,	1.04 ,,
Sulphur	0.018 ,,	0.010 ,,
Phosphorus	0 022 ,,	0 018 ,,
Manganese	0.53 ,,	0.22 ,,
Fracture at start	No. 1	Practically white
Fracture at finish	Grey porous	Close grey

was only half-burned coal, and, in addition, the blast pressure was frequently between 4 and 5 ozs., as this was considered necessary in order to reduce speed of melting. Any one of the above conditions was bad, but when all came together the result was disastrous, for what happened was that much of the unburned carbon from the coke was going into the ladle with the metal, and remained floating in suspension in the molten metal as carbon—really in this case, dirt.

Many instances have come under my notice where, through no fault of the iron, the analysis of the casting did not come out according to the theoretical analysis charged on the cupola. The reason is easily seen when standing on the cupola stage while the iron is being charged.

Condition of Carbon in Molten Iron.

This brings me to the old theory that all carbon in molten iron is combined with the iron as combined carbon. From works experience, confirmed by the examples just detailed, this theory seemed to be improbable. To prove this or otherwise, it was decided to take cooling curves of two samples of iron: (*a*) a virgin pig-iron, and (*b*) an alloy made up to the same analysis, or as near thereto as possible. Table 18 shows the two analyses. The grey iron was a hematite pig selected direct from the pig-beds, and the white iron was Swedish white of carbon 4.00 per cent., to which silicon 1.00 per cent. was added. It is further interesting to note that the hematite pig-iron was a grey No. 1 fracture, and the alloy was white, because it was chilled in cooling. These two analyses should have produced theoretically approximately the same cooling curves, but instead the No. 1 hematite pig-iron commenced to solidify at the theoretical percentage of total carbon about 2.00 per cent. instead of 4.20 per cent. This is seen in Fig. 2, showing that practically half the total

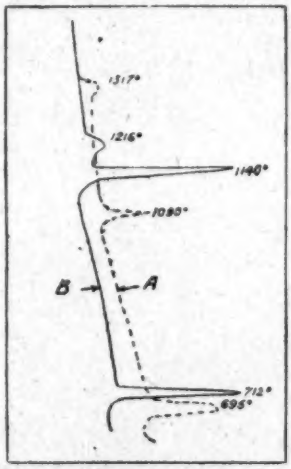


Fig. 2.—Cooling Curves of Irons "A" and "B."

carbon was not combined, but remained suspended in the molten metal. Further, to obtain more correct cooling curves it would have been necessary to take the temperature to about 1,300 deg. C. only, or just above the theoretical melting point of this analysis, but to give this old theory the greatest possible chance the temperature was taken up to 1,500 deg. C., the melting point of pure iron, because the higher the temperature the more carbon will dissolve. Therefore, had the commencing temperature of the curve been only 1,250 deg.-1,300 deg. C., probably still less of the carbon in the hematite iron would have been dissolved, and the first point of solidification would have been higher than shown. The alloy (*b*) commenced to solidify at the theoretical point and produced a beautiful curve, showing a perfect separation of graphite, suggesting that in this case the carbon was in such a condition as to dissolve in the molten iron, but the curve from the hematite iron shows little separation of graphite, confirming the higher point of solidification and showing that

approximately only half the carbon in this molten iron was dissolved, the other half floating about as free carbon. The practical application of these two curves to foundry practice is, that some irons in use commence to solidify at a much higher temperature than others, *because the graphite or free carbon exists as carbon floating about in the molten metal.* Such metal will not give solid castings, for it will be open iron when cold, and liable to "weep" under hydraulic pressure, because the carbon which is floating about in the molten metal commences to "grow" even whilst the metal is cooling. There is also the possibility that graphite, being intumescent, swells in cooling, the result being an open-grained iron with a vacuum between the molecules of iron.

Sufficient has been said to show that carbon—which is for practical purposes synonymous with fracture—is the controlling factor in the use of pig-iron, and also that total carbon and its character is controlled chiefly in the blast furnace.

It may be asked: Why has carbon such a controlling influence? It is because there is more than

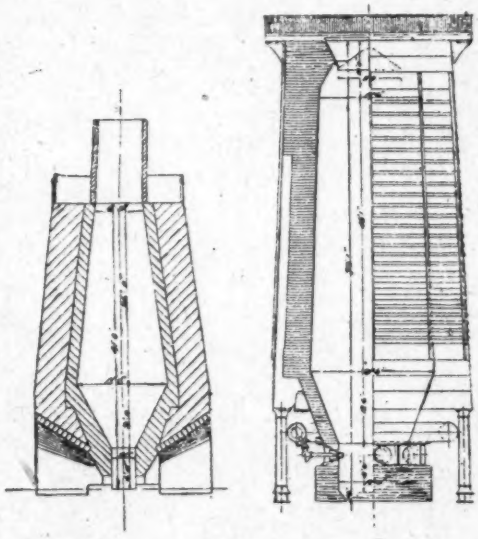


FIG. 3.—OLD AND MODERN TYPES OF BLAST FURNACES.

one kind of carbon, i.e., more than one kind of free carbon, or graphite, if that term is preferred. Foster, in a Paper given in Glasgow before the West of Scotland Institute, objects to the term combined carbon, which he holds is not correct. His opinion is that so-called combined carbon is carbon in solid solution. This opinion is quite in keeping with the two cooling curves just shown, which prove that about half of the total percentage of carbon in the case of the hematite iron was not in solution in the molten iron, and the other half which was in solution separated out on cooling, leaving only a small per cent. in solid solution. Putting the matter simply, the cooling curve from the hematite shows that carbon in commercial pig-iron is in two forms—one will dissolve in molten iron: the other will not—and it is a well-known fact in blast-furnace practice that the condition of the carbon is decided in the blast furnace. Further, of the percentage of free carbon in the hematite, part of this did dissolve in the molten iron, but the bulk did not, showing two physical properties of free carbon, or graphite. To continue this would lead into a long technical discussion, but there are signs that it is beginning to be a subject of greater discussion than any other element in pig-iron.

It is several years since I first suggested the differences in carbon, which was then disputed, but now things have changed, thanks to a large extent to the publicity given to the carbon question by the Editor of the FOUNDRY TRADE JOURNAL, in whose columns there has been considerable open discussion.

So far as one can judge, closeness of grain, and not analysis, is the secret of good tests and of solid castings, providing the melting conditions in the foundry are good. This swings round to the value of fracture, which shows to an experienced eye the condition of the carbon. To illustrate in a simple manner the difference between the conditions existing in the middle of last century in regard to blast furnaces, Fig. 3 shows a common type of furnace in use in 1844 and a modern blast furnace in common use to-day. The height of one is 26 ft., against the other, 80 ft. The capacity of one, 2,300 cub. ft., against 19,000 to 20,000 cub. ft. The production of one was 56, increased to 100 tons per week, as against 1,100 to 1,500 tons by the other, with many other distinctions. This illustration will be sufficient to demonstrate the totally different conditions existing in the manufacture of pig-iron in the early days, when little or nothing was known of its manufacture, from the conditions existing to-day; yet the differences in the character of graphites were suggested even in those days, and after nearly three-quarters of a century are beginning to recur.

(To be continued.)

National Service.

THE MINISTRY OF MUNITIONS are advised that apprehension exists amongst employers as to the effect of the instruction of December 18 upon the output of essential munitions of war, and that the semi-skilled and unskilled men who alone are affected by this direction are in some doubt as to their duty in the circumstances thereby created.

The Ministry, therefore, desire to emphasise the general consideration which governed the issue of this instruction—the supply to the Army of men fit for general service and under the age of thirty-one years. Under the procedure arranged no man debadged and decertificated by the General Instruction will be called to the Colours except after consultation and by agreement with responsible officers of the Government Departments concerned. These officers will decide where substitutes are necessary, and the substitutes will be offered to employers so as to secure the least possible disturbance in the output of munitions.

Apprentices of military age who comply with the provisions of the Trade Card Scheme, and who are classed on the register of their employers as semi-skilled, should be specially indicated on all returns made by employers.

The Ministry of Munitions desire to urge upon all men affected by the General Instruction of December 18 that it is their imperative duty to remain at their posts in munition works, and to continue to exert every possible effort to maintain and increase the output of munitions unless and until they are called upon for any other form of national service.

Initial Stress Produced by the Burning-in of Manganese Bronze.*

By Paul D. Merica and C. P. Karr.

The present investigation has been made in connection with the failure of manganese-bronze valve castings in the Catskill Aqueduct. Large castings of this material have after some months in service developed fissures, through which leakage took place under only a few pounds of pressure. In most cases these cracks appeared to be close to or in a repair made by the method of burning-in.

The castings are quite large, up to 22,000 lbs. in weight, so that neither preheating of the cast-

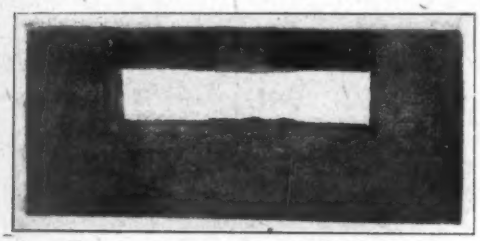


FIG. 1.—CASTING USED IN BURNING-IN EXPERIMENTS

ing for the welding or burning-in of defective areas, nor subsequent annealing of the whole casting could be conveniently carried out. As a result of the local heating of welding and consequent unequal contraction of different constrained parts of the casting, stresses remained in the casting, particularly severe near and within the burned-in areas; these stresses were in all probability responsible for the subsequent failure at these points. The determination of the values of such stresses, in the case of castings of manganese bronze, in corre-

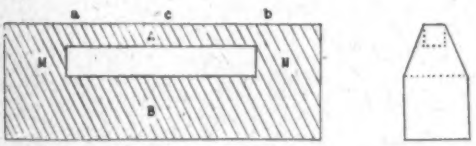


FIG. 2.—FORM OF CASTING USED IN BURNING-IN EXPERIMENTS.

lation with the physical properties and structure of this material as welded or burned-in seemed desirable.

The Measurement and Calculation of Stress.

For the investigation of these stresses, a form of casting, shown in Fig. 1, and in the sketch, Fig. 2, was chosen. It is a double-bar frame, the two cross-bars, *A* and *B*, having sections of area 1 by 1 in. and 3 by 3 ins. respectively, and being connected by heavy and stiff ends *M* and *N*. The inside length from *a* to *b* of the bars was about 9 ins.

A portion of the bar *A*, varying from ¼ to 2 ins. in length, was removed by sawing, and replaced by burning-in with the same material, care being taken to keep the bar, *B*, cool during the operation. The pouring gate for the burning-in was then sawed off, gauge points placed just inside of *a* and *b*, and readings taken with a strain gauge before and after sawing through *A* outside of the gauge point, at either *a* or *b*. Knowing the elastic modulus of the material and the contraction over the 8-in. gauge length, a direct calculation gives the value of the stress in the bar *A*.

Some interest attaches to the method by which the welding was accomplished. In all cases the casting was placed on its side and bedded in green sand; a pit was then hollowed out by hand around the severed ends of *A*, such as to expose these ends, and the bar, from ¾ to 1 in. back, and to allow a small channel-way, from 1-16 to ⅛ in. wide around the bar at these ends. The sand was here built up slightly and a hollow iron cylinder, about 4 ins. high, set over this pit, thus providing a sufficient pouring head. It was found necessary to preheat the ends to be welded, not only by means of a torch, but also by making a small reservoir in the sand directly under the burning-in pit, separated from it by sheet-iron plates, and pouring hot metal into this reservoir immediately before burning-in. No flux of any kind was used.

The molten metal was first poured into this reservoir, then into the pit, completely enveloping the ends and filling the pouring head. In order to be certain that the bar, *B*, of the casting was actually kept cool during the operation, this part was in several instances water-cooled while the weld was made. This was done by boring a 1-in. hole longitudinally through the centre of *B*, attaching pipe and hose and running water through during the operation of burning-in.

The material used was that of a large scrapped manganese bronze casting of the following composition :—

Copper ..	58.5 per cent.	Lead	trace
Zinc	39.1 „	Iron	1.4 per cent.
Tin	1.0	Manganese ..	none

This method gives uniformly sound welds. Table 1 gives the values of the tensional stresses found in the bar *A* of the various castings tested.

TABLE 1.—STRESSES PRODUCED BY THE BURNING-IN OF MANGANESE BRONZE.

No. of casting.	Length of Bar *A*, removed and burned-in.	Stress measured after burning-in.	
	in.	Lbs./sq. in.	Kg./cm.²
232a	0.25	9,600	680
232b	0.50	weld not sound	
232c	0.50	9,200	640
232d	0.50	8,500	600
232e*	0.50	8,500	600
232f	2.0	6,400	450
232g†	2.0	8,500	600

* This casting was annealed as described below before the stress determination was made.

† In this case the part B of the casting was cooled with running water as described above.

It is not difficult to make an approximate calculation of the stress in the bar *A*, which should result from the burning-in. Assuming that the co-

* Paper presented at Annual Meeting of American Institute of Metals, 1916

efficient of linear expansion is constant, that the temperature distribution along the bar A at the moment of solidification of the metal is equivalent to a temperature equal to that of the melting point of the metal over 1.5 times the length burned-in, that the stresses are at all times less than the true elastic limit of the material, and making approximate calculation for the stiffness of the ends M and N of the frame, the tensional stress resulting in A for every inch of metal burned-in should be 36,000 lbs./sq. in.

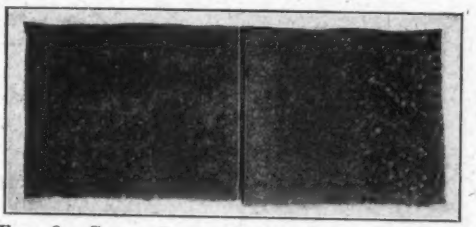


FIG. 3.—GRAIN STRUCTURE OF SECTION THROUGH BURNED-IN ZONE. ETCHED WITH AMMONIACAL COPPER CHLORIDE.

There results, actually, a stress of from 8,000 to 10,000 lbs./sq. in., irrespective of whether $\frac{1}{4}$ in. or 2 ins. of the bar A were burned-in This indicates, of course, that at some temperature, the resulting stress becomes greater than the elastic limit of the material, and the material yields thenceforth, the stress following (with probably some time lag) the elastic limit of the material, so that the stress, as measured, one or two days after burning-in, represents the true elastic limit of the material.

The Physical Properties and Microstructure of Burned-in Brass.

A tensile test was carried out on a specimen from the bar A of No. 232g, and gave the following results :—

Ultimate strength	.. .. ..	60, 000 lbs./sq in.
Proportional limit	.. .. ..	13,000 "
Modulus of elasticity	.. .. ..	15.4×10^6 "
Elongation in 5 in.	.. .. ..	19.4 per cent.
Reduction of area	.. ..	26 0 "

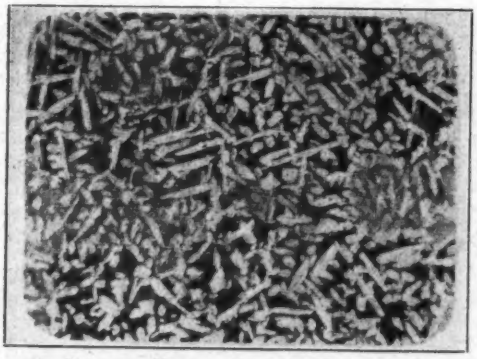


FIG. 4.—WITHIN BURNED-IN ZONE. Microstructure of Burned-in Bronze Casting.

The fracture occurred outside of the welded area, but not at the juncture of the original and the welded-in portions, and the welded-in section of the test piece was harder and less elongated than the original material. The fracture showed only a few minute flaws; it may be accepted, therefore, that the true elastic limit of the material was somewhat below the proportional limit in this case.

Consideration of the microstructure of the burned-in metal affords an explanation for its greater hardness. Fig. 3 shows the grain structure within and without the welded-in area of the specimen 232c. It is seen that the central welded portion is of much finer grain than the original material, as cast, on either side, and the transition from welded to original structure is very abrupt. In Figs. 4 and 5 are shown the microstructures, inside and outside respectively, of the burned-in zone. The structures are those of normal manganese bronze, there being no difference in the two other than that of size of grain. No evidence of overheating or of burning-out of the zinc near the juncture of the zones was noted.

The bar A of casting 232h, with 2 ins. burned-in, was brushed over continually with a solution of mercurous nitrate for about two weeks, but showed at the end of that time no fissures or sign or failure.

A small portion, about 6 ins., of the bar A of the casting 232e was wound with nichrome wire and the bar thus locally anneal-heated at a temperature of 300 deg. C., for about one hour. The stress in the part A remained unchanged by this treatment. It may be noted that if it is wished to relieve the stresses in A by some heat treatment affecting it only, the part B being kept at the ordinary temperature, the part A should be cooled 50 or 100 deg. instead of being heated.

Conclusions.

The experiments described have indicated how readily severe stresses may be introduced into a casting by the burning-in or welding of a "constrained" area or portion of it. The form of casting used in these experiments was such that no bending or distortion, tending to relieve the stresses, was possible during cooling, and this must be borne in mind in applying these results to the consideration of the effect of burning-in of more complicated shapes, where such distortion does occur.

In the spherical shell or dome-shaped valve castings under discussion, for instance, burning-in

FIG. 5.—OUTSIDE OF BURNED-IN ZONE. Etched with Ammonium Hydroxide. x about 80.

would tend to flatten the shell, and in so doing, partially relieve these stresses, and it is most difficult to calculate the stresses in such a case. The authors are inclined to believe that even in these cases local stresses of values equal to the true

elastic limit must have been produced, and which would account for subsequent failure.

The conclusions to be drawn, therefore, are :—

(1) That the welding-in of constrained portions of castings (forgings, wrought articles, etc., naturally, as well) of manganese bronze, produces in general local initial tensional stresses within and near the burned-in zone, of value equal to the true elastic limit of the material, unless the shape of the casting is such that extensive distortion may occur.

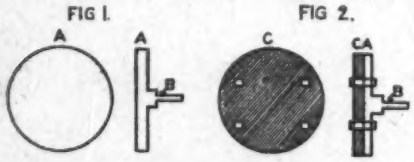
(2) That such castngs should, therefore, be either pre-heated carefully for welding, so that all parts of the casting cool down together from a dull red heat, or the casting should be subsequently annealed. Experience indicates that a low temperature anneal is sufficient for this purpose, e.g., from 400 deg. to 500 deg. C. (760 deg. to 945 deg. F.) for from one to two hours. Either of these precautions should eliminate these local stresses resulting otherwise from the burning-in and should produce castings free from danger of subsequent cracking.

Foundry Tumbling Barrel.

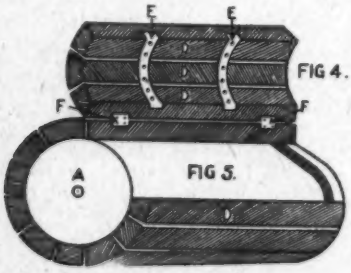
By A. Smith.

Some time ago, having a very large quantity of small castings to supply, we decided to build a small rattler, or tumbling barrel, as the large

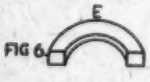
FIG 1. FIG 2.



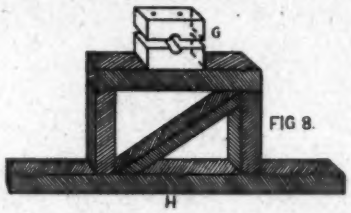
iron ones caused a great deal of breakage. The measurements of the new one were 15 ins. inside and 3 ft. long, this holding a barrow-full at a



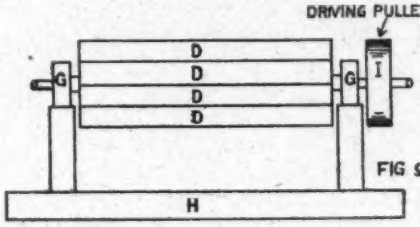
time. The method was as follows :—Cast two discs 15 ins. dia. and 1 ft. thick, and a spindle as shown at B, Fig. 1. Make two wood discs and



bolt on to face at Fig. 2, CA. This method saves drilling and machining, for the wooden bars, D, Fig. 3, can be screwed on to the disc. The lid, Fig. 4, is of three bars screwed on to sections of wrought iron bent to correct angle, Figs. 4 and 6, E and D, and mounted as shown in Fig. 5 by hinges F. Next cast two blocks for bearings, and drill through as shown in Fig. 7, G. The standards are of timber, 3 ft. by 4 ft., Fig. 8, H; these can be bolted to the floor.



The whole thing was put together by a carpenter, and cost only about £3. It can be attended



by any lad, and proves a most serviceable and cheap tool for very light and small castings.

REFRACTORIES.—According to Dr. Stansfield, of the Canadian Department of Mines, electric steel furnaces in the United States, Canada, and elsewhere have been very seriously handicapped by the extreme difficulty of obtaining magnesite bricks after the outbreak of war, as the magnesite for their manufacture used to come from Austria. The Canadian magnesite obtained from the Calumet district is not altogether ideal for the production of firebricks as it does not sinter on burning and its lime contents are rather high, being frequently in the neighbourhood of 10 per cent. Experiments have been made in which iron ore was added so as to cause it to sinter, thus producing a dense product suitable for lining furnaces or for making bricks. Mr. H. J. Ross, of the North American Magnesite Company, states that their magnesite has been used in large quantities for lining open-hearth furnaces, the burnt magnesite being mixed with basic slag as in the ordinary practice, and this has the effect of causing it to sinter in the furnace. They have even been able to dispense with magnesite brick in these furnaces, as is indicated in the following instructions supplied by him :—The crude magnesite is partially burned—say four or five hours in an ordinary heating furnace, but, if more convenient, a cupola, or rotary kiln, or a continuous heating furnace may be used. Then draw and mix it thoroughly on the floor with 10 to 15 per cent. of good basic slag. Put it in the bottom of an open-hearth furnace and treat it like Austrian magnesite. This material has proved, where back walls are made for rolling or tilting furnaces, equal to any material ever used. One of the advantages of it is that the bottoms can be set in one-half the time required by the Austrian magnesite. The material has been in use in one plant for the last eight months where it could be compared with the Austrian magnesite, and with the disadvantage of having no magnesite brick. In this case the hearth was lined entirely up to the slag line with clay brick, and after this eight months' test the results were found to be fully equal to the Austrian magnesite. Exceptionally fine results are obtained by using it for closing tap holes.

Influence of Gases in Iron and Steel.

Discussion at Birmingham Branch of British Foundrymen's Association.

(*For Paper see last issue, page* 19.)

The BRANCH-PRESIDENT said that, with regard to the sketch in Fig 14, he understood the outer mass of metal was poured first round the steel tube in the centre, and then the metal was poured in the interior of the steel tube. If this was so, he thought the reason the inner casting showed no contraction when cool at points A and B was, the steel tube first expanding, due to the hot metal on the outside, and therefore being of larger diameter when the tube itself was filled. The whole would then contract normally, leaving the tube the same diameter as at first. He (Mr. Shaw) had a similar experience. Having to make in a hurry a column 20 ft. by 21½ in. diameter by 2 in. thick, it was struck up in loam in cast-iron casings, allowing only ¾ in. of loam. Coming out of the stove very hot, it was quickly cored, put on end, and cast at once. Having little loam on, the heavy metal of the column caused the iron casing to be quickly dull red. When the casting was taken out, it was found to be the same length as the pattern, due, without doubt, to the expansion of the mould before the column set.

PROFESSOR TURNER said the lecture gave them a good deal to think about, although he was not quite sure that he agreed with all Mr. Fletcher had said, especially in regard to the gases. No doubt what Mr. Fletcher told them was true as to the happenings in the furnace; the only question was as to whether they went the whole distance with him in his explanations. It had been suggested that, because in certain cases they got an ingot with columnar structure, that condition had been produced by the rising of gases upwards through the casting, and that the free flow of gas produced the blow-holes and unsound structure. If they looked at the Giant's Causeway, they would see great blocks of basalt separated and jointed into hexagonal columns. As far as they knew, there were no gases operating in the formation of those columns, and the structure they found there was due to shrinkage during cooling, at a particular stage of cooling, and appeared to operate apart from gases. Gases might or might not be there, but their presence had not been proved, though Mr. Fletcher gave that as his explanation. When one came to study the effect of gases upon iron, one met with some apparently quite contradictory facts, and some ground had still to be explored before definitely agreeing with Mr. Fletcher. Iron when cold and pickled, would take up hydrogen, and the metal was liable to become brittle. That hydrogen could be got rid of by heating the metal in air. Taking galvanised sheets for example, if not heated they might be brittle; but if the remaining hydrogen were eliminated, soft iron would be got. Heating in that case liberated the gases.

In the experiments carried out by Mr. Wesley Austin in the Birmingham University Laboratory, a short bar of metal was taken, and an increasing electric current passed through it, so as to heat it gradually. It was surrounded with a vacuum, and the gas pumped out as it came off, and it was observed that, as the temperature was raised to a certain extent, gas was liberated. But as pumping was continued, no further gas was got until the temperature was increased, when more gas was given off, and, if the temperature was increased to the melting point, there was a further liberation of gas. It was concluded that heating the metal apparently liberated the gas—not cooling it.

In regard to copper and hydrogen, if copper were heated up to its melting point, it was found that, as the melting point was approached, the proportion of hydrogen absorbed increased, and as it melted the solubility of the gas further increased. So that starting with molten copper, the temperature being well above the melting point and keeping it in hydrogen it was found that as it cooled it gave up hydrogen. In all probability iron did the same with carbon monoxide and hydrogen and nitrogen gas. It was known that when steel was poured into a mould hydrogen and carbon monoxide were given off. But he was unaware of any series of determinations in which the equilibrium conditions for the gas and the metal had been obtained. It appeared that up to a certain temperature gas was given up and the solubility decreased, and that, starting from a much higher temperature, as the temperature fell to a certain point the solubility also decreased. That seemed to be the evidence at the moment. The lecturer had stated that there was a large quantity of carbon monoxide in the blast furnace. As an extreme illustration they might think of a lamp-post in the open air. Any quantity of air was blowing round it, but how much of it went into it? They must not assume that because gases and metal were together that therefore they combined. If they did combine what was the effect on the mechanical properties? There was a solid solution as long as the gas remained dissolved. A practical example of that was nitrogen. It was well known that if nitrogen were added to pure iron forming a solid solution, the tenacity would increase in proportion to the nitrogen added, and the yield point also would rise materially, and the ductility would decrease. That was the ordinary result of a solid solution. With regard to the question of obtaining solid castings, they had to determine up to what point in cooling of metal gases were given off, and by that means they would get the most solid castings. If the temperature was too low, at what was ordinarily called cold metal, or just above its melting point, and the metal was poured it would be thick, and therefore the gas would not be able to escape and the bubbles would not have time to develop, with the result that a bad casting would be got. But reasonably hot metal would allow the gas time to escape, and a sound and stable casting would be got. With overheated metal, whether iron, brass or copper, the result would be a spoiled surface because the sand would be partly melted, giving a rough surface, which was not what was wanted. Again, with overheated metal the gas might be entrapped in the metal, and that was one way in which the blow-holes were got with superheated metal. There was obviously a proper temperature above or below which a bad casting would be got.

With regard to the effect of manganese on silicon iron, Mr. Coe and Mr. Hague did some experiments in that line which showed the remarkable effect produced by the addition of 0.5 per cent. of manganese. When dealing with pure iron, carbon and silicon, the addition of manganese would make the iron more grey by throwing out finely divided graphite. A new volume of the memoirs of the

Carnegie Research scholars had just come to hand, and the first related to researches by Mr. Andrews on iron, carbon and silicon. In that research Mr. Andrews started with iron, carbon and silicon containing about 0.75 per cent. manganese. He (Mr. Andrews) did not take any notice of the fact that he had iron containing a considerable and critical quantity of manganese. He then proceeded to carry out a considerable number of experiments with a view to recasting the equilibrium diagram. In other words he was arguing on experiments made with iron with which he never ought to have started. He mentioned that matter because the effect of manganese on the carbon in silicon iron had been shown independently both by Mr. Fletcher and in the University laboratory, and as to that effect there was no doubt whatever.

Mr. F. Johnson referred to a slide showing the eutectic structure of white iron. It appeared very much like a honeycomb, and the lecturer attributed that honeycomb structure to the formative influence of dissolved gases. He (Mr. Johnson) thought that did not necessarily follow. If a metal known to be free from gas were alloyed with an element which would form a eutectic alloy—for example, pure copper free from gas could be melted with phosphorus in such a manner that no gas could obtain access—such an alloy under the microscope would show just that honeycombed structure shown in the case of white iron. That would demonstrate that a honeycombed structure could be got without the presence of gas. Another slide exhibited a curious upward direction of the crystallites. It was a section of an ingot in which the crystallites growing from the sides had an upward direction. He gathered from Mr. Fletcher's remarks that he attributed that upward direction to the presence of gases—that the gas in attempting to rise had compelled the crystallites to follow it when growing through the bath of liquid metal. He thought the action was the reverse of that described. The crystallites growing from the sides of the ingot were prevented at a certain stage from growing horizontally, because they met with the upward growing crystallites from the bottom, and therefore they had no other way to grow except upwards. There was a general course upwards, but that was due to the more rapid cooling in the bottom portion of the ingot rather than to the directional action of the gases.

Mr. Fletcher had referred to the existence of phases and constituents in a molten condition—for example, the eutectic in white iron and also the iron-carbon solid solution. Mr. Fletcher assumed that those constituents were already existent whilst the alloy was in the molten condition. He (Mr. Johnson) thought they got such an extraordinarily complete molecular admixture in the molten condition that they could approach the question from another point of view. They could assume that the admixture was so complete that it was not necessary to regard constituents such as solid solutions and eutectics as existing in the molten condition. They could safely assume that the nuclei which first solidified were those which had the highest freezing point, leaving the others to follow in their natural order.

The point to which Professor Turner referred, that of the high temperature being a detriment in the case of copper, was one to which he (Mr. Johnson) was about to refer. It was a fact that copper and copper alloys showed greater solvent power for gas with increase of temperature of the molten metal. That seemed to be the reverse of the case to which Mr. Fletcher referred, although doubtless if his molten metal became still hotter he would get trouble by the greater solution of the gases in the metal. Hydrogen, which was very soluble in molten metal, seemed to be the gas to which most foundry troubles were due, not only, as Mr Fletcher pointed out, in the case of iron and steel, but also in the case of copper, where that greater solubility was got, and there might be hydrogen present by the dissociation of hydrocarbon gases and water vapour. In copper was also got a solution of carbon monoxide, but on the whole hydrogen seemed to be the most soluble gas of the gases with which they had to deal. Dr. Kemp, in one of the Carnegie Scholarship memoirs, showed as much as 1,000 litres of hydrogen were contained in a ton of steel. That naturally led to the point concerning the condition in which hydrogen and other gases existed, and it had always occurred to him that the influence of what were called degasifying elements such as phosphorus in copper, aluminium in steel and silicon in steel was the rejection of the gases—the throwing out of the gases before solidification started to take place. For instance, starting with copper containing gas and using phosphorus as a degasifying element, one got a sound casting. If phosphorus were not added an unsound casting would be got. If one started the other way, and added a degasifying element to copper containing no gas it was found to be almost impossible to produce an unsound casting. The natural inference would be that the added element threw out the gas that was in solution. That was his own opinion for some time, but Baker's experiments carried out on steel showed that of two ingots, one unsound and the other sound, the soundness of the latter being due to the use of aluminium, the sound ingot gave off in vacuo twice the volume of gas that was given off by the other. Such experiments would suggest that the added element helped in the retention of the gases. So they got very conflicting results from different experiments, and it was still also an open question as to the condition in which gases existed in the solidified metal.

Mr. R. Buchanan said he gathered that what foundrymen called liquid contraction holes Mr. Fletcher called gas holes. Foundrymen distinguished between a gas hole and a contraction hole from the fact that with a gas hole the interior of the hole was usually smooth, whereas a liquid contraction hole was usually rough. There was also a difference in colour, the liquid contraction hole being darker than the other. Another remark was rather along the line of some of his (Mr Buchanan's) ideas. The question was whether iron made in the blast furnace maintained its character —in other words, did the quality persist? If that was so it was a most important point. With regard to the quantity of gas in the casting, there was no doubt a large quantity there. Professor Carpenter in certain experiments found that the riser from the casting contained more gases than the metal did, which rather supported Mr. Fletcher's contention. With regard to iron taking more gases into itself at a high temperature than a low one there was very little doubt about that. There was also very little doubt that the gas was given up as the metal was cooling, and that the mould ought to be of a porosity sufficient to allow the gas to go up the metal through the mould. Mr. Rhead, of Manchester, once mentioned that he was very much puzzled over the unsoundness that appeared

in certain castings. He could find no reason in the metal itself. He found there was too much clay in the black-wash, and so he used black-wash which was much thinner and more porous, and the unsoundness disappeared. That showed that the mould was too dense to allow the gases to pass through.

MR. F. J. COOK referred to the three ranges of temperature which Professor Turner mentioned as giving either good or bad castings. A low temperature was always associated with blowholes. But it was possible to have blowholes with a higher temperature. If iron were cast with the metal boiling there would equally result blowholes. With regard to iron maintaining its characteristics from the blast furnace to the finished casting, that was referred to by Mr. Hailstone and himself (Mr. Cook) in the research they conducted on the structure of strong iron. Strong irons undoubtedly carried their blast-furnace characteristics straight through, and of that he could give many illustrations.

MR. FLETCHER, replying to the discussion, admitted that some of his conclusions might still be regarded as unproved. But practically they had been proved in experience of manufacturing satisfactory castings working on the lines described in the lecture. The gases liberated during solidification had considerable influence on the crystalline structure, and realising this fact he had been able to make castings that at one time were supposed to be impossible to manufacture. Professor Turner raised a point about the effect of the gases on raw materials in the blast furnace. There the hot metal particles were surrounded by gas, and therefore gas could be supposed to penetrate the metal. He (Mr. Fletcher) mentioned that as a possible reason why they might expect the presence of CO gas in the cast iron. As far as he could see there had been no proper explanation given from any source why there was always CO and hydrogen in the casting. It was also clear from experiments made with cast iron from various parts of the furnace that there was chemical combination between the moisture in the blast and the carbon incandescent in the tuyere zone. It seemed reasonable to expect that when the gases were there and steam was associated with them they would unite to form carbon monoxide.

It had also been mentioned that the stream lines to which he drew attention in the structure of the eutectic had possibly nothing to do with the gases. Personally he could not understand those flow-lines being there unless some such action had taken place. He had produced many illustrations of the fact, and he had some scores of illustrations of ingots which had been cast, and he had shown the parallel directions of the gas paths and of the crystal axes in a whole series of iron-carbon alloys containing aluminium, silicon, manganese and chromium. These were made not for laboratory purposes alone, but for the purpose of showing the influence of those alloys in the making of tool and projectile steels. Some of the research was fifteen years old, and a great deal of the work done ten or twelve years ago was just beginning to filter through. Naturally, when one was engaged on such work it was not always policy to give away the knowledge to the wide world. But they saw gradually one laboratory after another bringing forward matter covering ground that had already been gone over years ago.

As to the remarks about liquid crystals, he thought Professor Howe had thrown out a great many suggestive thoughts about that matter during the last few years in his last book on the "Metallography of Iron and Steel," and that book was most interesting from the cast-iron standpoint particularly. He should recommend any foundry student who wished to go deeply into the subject of the theory of the manufacture of cast iron or steel—they were practically one, for the two were allied—to read that last book of Dr. Howe's which covered some of the matters he (Mr. Fletcher) had dealt with. Personally he had never yet been able to understand, if gases had nothing to do with the direction of the crystals, why those crystal axes in one of the views shown were deflected down hill right away down to the base of the ingot. He followed up that series by making a number of ingots in slag. Slag gave some remarkable results in connection with the study of gas escape. He had some correspondence with Dr. Stead on the subject, and Dr. Stead said he could not be quite certain which was first: whether the crystals followed the gases or the gases followed the crystals. His (Mr. Fletcher's) experiments led him very strongly to the conclusion that the crystals were in some cases bound to follow in the direction of the flow of the gases.

The question of hot castings had been raised by Mr. Cook. He did not think that in the lecture just given he had gone against the theories of Mr. Cook and Mr. Hailstone on the points raised. But he had not mentioned the fact that a superheated condition was a dangerous one, although that was a fact. There should be a proper casting temperature in the region of the melting of what he called the primary crystallites if a sound metal was to be got. When the primary crystallites began to be overheated a gas-porous condition was got largely through the primary crystal giving up all its gases, and possibly becoming oxidised.

Mr. Buchanan had raised the question of liquid contraction holes. He (Mr. Fletcher) certainly held the opinion that liquid contraction had to do with gas just as certainly as with so-called gas holes What were called shrinkage holes were rather liquid contraction holes. It was quite possible that at a high temperature some gases—carbon monoxide particularly—might have brought about the carburising of the crystals which began to grow around the interior of a large blowhole. He thought that shrink holes and gas cavities were part and parcel of the same thing. If they could get the gases clean away they would get neither gas holes nor shrinkage cavities.

Soldiers and Civil Work.

The Secretary of the War Office makes the following announcement :—

Certain employers have been making a practice of writing letters direct to soldiers on active service, or to their officers, urging the release of the men in order that they may return to their employers. Such interference is opposed to the maintenance of discipline, has an unsettling effect on the men, and is also open to other serious objections. Particular attention is, therefore, directed to the provisions of the new Defence of the Realm Regulation, 42 (B), under which, if any person, without the consent of the Admiralty, or the Army Council respectively, communicates, either directly or indirectly, with any member of his Majesty's naval or military forces, or with the commanding or other officer of such member, with intent to induce or assist such member to obtain or apply for his release, transfer to the Reserve, or discharge, so that he may engage in civil employment, he will be guilty of an offence against the regulations, punishable on summary conviction. The regulation does not apply to communications with or by a Government Department.

Fire Prevention and Protection.

It is estimated that during the month of June last the total loss caused by fires in the United Kingdom amounted to £180,200, while 5 men, 10 women, and 35 children lost their lives. Reviewing the loss for the war period up till the end of June, the figure has now reached the enormous sum of £6,891,050. It must be remembered that these figures only represent the material loss sustained, and take no account of the loss due to dislocation of business, loss of profit on unfinished contracts, loss of goodwill, and other items which it is difficult to compute in terms of money.

Apart from the involved peril to human life, this continual drain upon the resources of the country is one of the strongest arguments for first-aid fire appliances. The time is surely coming when both commercial and residential buildings will all have to be protected by an efficient equipment of first-aid apparatus. According to MR. F. H. WENTWORTH, in a Paper read before the American Foundrymen's Association, American statistics show that the average annual *per capita* fire loss in six European countries is 1s. 4½d., while the average *per capita* loss in the United States is 12s. 6d., and in Canada 12s. 9½d. Glasgow has an annual fire loss of £65,000. Boston, U.S.A., smaller than Glasgow, has an annual fire loss of £400,000.

In the Paper referred to above Mr. Wentworth reviews the fire records of foundries in America, and gives the accompanying table.

FOUNDRIES—FIRE RECORD.

Total number of fires reported, 475.

COMMON CAUSES.

	No. of fires.	Per cent. of common causes.	Per cent. of known causes.
Heating	16	18.6	4.4
Lighting	12	14.0	3.3
Power	9	10.5	2.5
Lightning	4	4.6	1.1
Boiler (or fuel)	9	10.5	2.5
Oily material	5	5.8	1.4
Rubbish (or sweepings)	3	3.5	0.8
Locomotive sparks	19	22.1	5.1
Smoking	4	4.6	1.1
Miscellaneous	5	5.6	1.4
Total	86	100.0	

SPECIAL HAZARD CAUSES.

	No. of fires.	Per cent. of special hazards.	Per cent. of known causes.
Cupola	112	42.7	30.7
Sparks from	87		
Heat from	14		
Miscellaneous	11		
Core oven	40	15.3	11.0
Moulding, pouring and casting	34	13.0	9.3
Furnaces	25	9.5	6.9
Hot castings	8	3.0	2.2
Slag	1	0.4	0.3
Flasks	7	2.7	1.9
Fuel oil	8	3.0	2.2
Dip tank	2	0.8	0.6
Charcoal	2	0.8	0.6
Asphaltum or tar dipping of pipes	5	1.9	1.4
Phosphorus	3	1.2	0.8
Miscellaneous	15	5.7	4.1
Total	262	100.0	
Common causes	86	23.6	
Special hazard causes	262	72.0	
Incendiary	8	2.2	
Exposure	8	2.2	
Total known causes	364	100.0	
Unknown causes	111		
Total	475		

A waste of 12s. 6d. *per capita* per annum means that every man, woman and child pays 12s. 6d. a year for fire waste. That means that the average family—five persons—pays over £3 a year fire tax. The United States Government in its report adds to this fire waste the cost of maintaining fire departments, which is as much more. This means a total of £6 a year to the average family.

The fire waste touches the pocket of every man, woman and child; it strikes as surely, but as quietly as indirect taxation; it merges with the cost of everything we eat and drink and wear. The people feel it without yet being awake to its cause. Their awakening is retarded by the prevalence of the foolish notion that the insurance companies pay this colossal tax. But how could they, and remain solvent? They are mere collectors and distributors of that portion of the tax which is represented by their policies. Half of it they never tuoch; it falls upon the householder direct.

The suggestion has been made that we must begin to place the responsibility for preventable fires upon the individual. In France, if one has a fire and that fire damages one's neighbour's property, one has to pay the neighbour's loss. Inquiry should be made into the causes of all fires, and not merely into the fire which is suspected to be the work of some incendiary. Nearly every fire is the result of some carelessness.

The question of fire is always of paramount importance, and probably few of our readers have come across information as to the extensive precautions that are taken to guard against it in America. Practically every steel plant maintains its own private fire brigade. To quote one or two instances: the Bethlehem Steel Company has a thoroughly drilled fire force of about 200 men. The various subsidiary companies of the United States Steel Corporation employ a total of several thousand, a goodly number of whom, however, are volunteers employed in other capacities, but who are paid a substantial bonus for attending fire drills and studying fire conditions in general.

Such devices as a complete signal alarm system, motor and horse-drawn chemical fire engines, hose connections, hand fire-extinguishers, etc., are common to every works. Those that are on a water front maintain large fire-fighting tugs, some of which have a discharge capacity as high as 12,000 gallons per minute.

One works in particular maintains a fire-fighting train, made up of two flat cars, on each of which are built two water tanks, each tank containing five thousand gallons, or a total of twenty thousand gallons for the train. An additional wagon carries the hose. The pump is placed in the space between the two tanks, and is used to force the water out when fighting fire. Steam is taken from the locomotive to run the pump, and three lines of hose can be in operation at one time if necessary. The following is abstracted from a description of the arrangements at the Bethlehem Steel Company's plant:—

A building which may be built along entirely modern lines and absolutely fireproof in construction, is not fireproof if it contains inflammable material. This statement of facts might seem quite unnecessary; however, it is almost unbelievable how many persons really entertain the opposite opinion.

In considering preventive measures in connection with modern shop construction, the shop interior is indeed a matter of major importance. Practically all of the buildings at Bethlehem (all permanent buildings) are constructed of brick and steel, equipped with

heavy glass windows set in steel sashes. Such construction will prevent fire from spreading from one building to another, but if a fire in any one of these buildings must be fought from the outside, serious difficulty will be encountered. It is practically impossible to break wire glass windows enough to permit the entrance of any damaging amount of water, and a fire of this kind, unless fought from the inside, is more than likely to cause serious losses.

In a large number of shops there are numerous machines of various types requiring large quantities of oil in their operation. Each one of these machines has its own reservoir and the constant operation of such machines in a short time makes the surrounding floors literally oil-soaked; this, of course, applies to buildings of more than one floor, where the floors above the ground floor are constructed of wood. The oils as used in machine operations of this kind are classified as non-inflammable and in every instance show exceedingly high flash points; nevertheless, the possibility of an oil fire has been carefully considered and proper provisions made to handle such an emergency.

In the more recently constructed shops wooden floors and roofs have been entirely eliminated, the entire interior construction being of concrete and steel. All beams and girders are encased and the possibility of loss due to oil fires has been reduced to a minimum.

Although there are some shops where the fire risk is practically nil, every department in which there is any fire hazard whatsoever has been completely equipped with small hand extinguishers, the Pyrene extinguishers being used for a greater part of this service. These extinguishers, together with a limited number of 2½-gallon soda extinguishers, are available for ready use and have been located in readily accessible places, so that, in case of an emergency, the workman need not go, in any case, a distance of more than 30 ft. in order to have access to proper apparatus for fighting a fire. All fires are the same size in their incipiency, and it is only a matter of getting at one quickly with proper equipment.

A number of 40-gallon chemical trucks have also been stationed at various points about the plant, these trucks being placed inside of the shops and at the ends of the main aisleways. It has been successfully demonstrated on several occasions that this equipment can be brought quickly to the scene of any fire, and the quantity of chemical available in such cases is, as a rule, far in excess of that actually required to extinguish the average fire. Chemical equipment is really excellent in fighting fires if it can be brought into use in the very early stages of a fire, and for that reason equipment of this kind must be available immediately, or it is practically worthless.

To better cope with possible oil fires in certain departments, a considerable number of portable sand trucks have been built and installed where necessary. Sand buckets are also to be found at regular intervals about these departments for ready use, scoops being attached to each bucket to facilitate the handling of small quantities of sand, which oftentimes is sufficient to extinguish small oil fires.

After a fire is well under way, it is then a matter of proper equipment and lots of it, for in that stage it is a question of fire fighting. Realising the importance of this fact, the Bethlehem Steel Company has provided, in addition to the above-named portable hand equipment, an independent high-pressure fire line and automatic sprinklers in the various departments.

The independent high-pressure fire system supplies water at 400 lbs. pressure, extending into various shops with numerous outlets for standard 2½-in. hose connections on the floors of these shops. Fire plugs are located outside of all the shops, these plugs being connected to the 400-lb. pressure lines.

Automatic sprinklers have been installed in a number of the shops for several years, and at the present time two of the large machine shops are being equipped with this system. These particular shops, while practically fireproof in construction, present certain fire hazards due to the nature of the work and material being handled within them, and therefore the installation of automatic sprinklers has been considered necessary.

Although adequate fire equipment is most essential, if nothing further is done fires will continue to occur and many of them will cause considerable damage. Organisation is a real factor in fire prevention work and it is this organisation which is being developed at Bethlehem to-day. Fire inspectors are detailed in every department of the plant in which fire hazards in any form are known to exist. These inspectors report direct to a fire chief and their entire time is devoted to making regular inspections of all departments. Smoking has been prohibited in practically every department of the works, and the inspectors are responsible for the enforcement of such regulations. They are also responsible for the upkeep and inspection of all fire equipment within their district, and are constantly on the lookout for any conditions which might be termed unsafe from a fire prevention standpoint. Good housekeeping is the one thing never to be lost sight of in a work of this kind, and one of the principal duties of the fire inspector is to keep his district clean at all times. The plant is constantly under the surveillance of the fire inspectors, these men working in shifts covering the entire twenty-four hours of the day.

In addition to these regular inspectors, arrangements have been made to maintain a fixed force on both day and night shifts, to be stationed at a central hose house where a motor hose truck, fully equipped, will be housed.

Working in conjunction with the above organisation a volunteer department is maintained. Several hand-hose trucks are stationed at various points about the plant, each truck having its foreman and crew on both day and night shifts. Each one of these trucks carries 500 ft. of 2½-in. standard hose together with nozzles, axes, lamps and other necessary equipment.

A complete fire alarm system, modern in every detail, is now being installed, replacing the old system. The new layout is entirely automatic and divides the plant into seven general zones, each zone being subdivided into districts, requiring thirty-seven alarm boxes to cover all of the seven zones. When an alarm is sent in, the signal is given on a whistle circuit, whistles being located at different points about the plant. All boxes are indicated by a two-digit number, the first number in each case indicating the zone, while the second number indicates a definite district within that zone. In none of the zones are there more than nine boxes, this number being sufficient to completely cover all districts.

Among the many causes of fires are:—(1) Improper installation of electrical equipment of all kinds. (2) Steam pipes, belting, etc., coming in contact with other material through slack or faulty workmanship, such as failure to use proper fuses, insulators, etc., on electrical work, and failure to use sleeves, iron brackets, collars, clearances and insulated pipe coverings on high-pressure steam lines. (3) Careless and improper storage of oils and larger amounts of oils being kept on hand than actually required, stored in broken cans without stoppers, etc., in close proximity to open fires. (4) Grease kept in open pails. This is not only a fire hazard, but grit and dirt accumulate in same which is harmful to machinery, etc. (5) Cotton waste and rags, both new and old oil-soaked, stored in lockers or wooden bins, and left lying about. (6) Old oil-soaked overalls thrown in out-of-the-way places or stored in lockers. (7) A lack of proper housekeeping conditions and cleanliness. (8) Lack of fire doors and fire shutters and automatic trap doors for elevators. (9) Improper storage of oil, clothing, etc.

Temporary buildings of combustible material erected as a lean-to against important buildings, create a hazard and might cause fire enough to endanger or melt an I beam, or put a machine out of commission, entailing loss in production, etc.

The Functions of Feeders and Denseners.

A discussion on "The Functions of Feeders and Denseners" was opened by Mr. J. J. Howell at a meeting of the Birmingham Branch of the British Foundrymen's Association on December 9, Mr. J. Shaw (Branch President) in the Chair.

Grey Iron.

Mr. Howell dealt with feeding and chilling in regard to castings of grey iron. Mr. Fletcher, in the paper presented at the last meeting (see our last issue) assumed that feeding was necessary to facilitate the escape of occluded gases in the molten metal. With this he (Mr. Howells) did not agree; but he did agree that, if gases followed a known law and converged to the centre towards the mother liquor, feeding with a rod would help those gases to escape. But if Mr. Fletcher meant to convey that gases were the sole cause of cavities, and that if the gases were eliminated from the metal the cavities would not occur, he thought Mr. Fletcher was wrong. With or without gases, he was certain that feeding was necessary for the production of sound castings of great bulk. That cavities were formed in castings by occluded gases he did not doubt, but he was equally certain that there were also shrinkage cavities due to the presence of an impoverished mother liquor. This could only be rectified by keeping in touch with the mother liquor, and feeding into it new iron that would supply it with the necessary material for the building up of tight crystalline mass.

To understand why feeding was necessary, and how to feed properly, it was necessary to have some knowledge of the changes which took place in cast iron when passing from the liquid to the solid state. If cast iron, after being poured into the mould, solidified without any change taking place, feeding would not be necessary, for it was an accepted fact that cast iron in the molten state is a homogeneous mass with all its constituents in solution, and if quenched in that condition becomes a hard, white, crystalline mass. Under commercial conditions, cast iron was rarely cooled as quickly as that; therefore, the elements were not trapped in solution, but time was allowed for them to separate out—the longer the time allowed the more perfect the separation. To help to a more perfect understanding of the changes that took place, one might imagine that a large mould had just been poured. The metal poured might be considered to be a saturated solution of carbon, silicon, sulphur, phosphorus and manganese in iron. Cooling would commence at once, all the faces of the mould and cores being cooling surfaces; the liquid iron would give off heat waves which would be conducted away by those cooling surfaces, and along those heat waves would be carried the crystals that first began to freeze out. These primary crystals would thereby become arranged at right angles to the cooling surfaces. The composition of these crystals was of secondary importance to the immediate discussion, and he would leave that out of the question.

It was sufficient to know that crystals did freeze out, and that these primary crystals were richer in iron than the crystals that would immediately follow. The point that he wished to emphasise was, that if these first crystals did take with them pure iron, then of necessity the molten iron left behind would become richer in impurities; and as the temperature fell a little lower, other crystals would freeze out, these also taking with them a big percentage of the iron left. One could well understand that if this process was being repeated over a length of time, the iron which remained molten for the longest period, what was termed the mother liquor, would become a concentrated mass of impurities. That was where the value of feeding came into operation; with the aid of a rod one kept in touch with the impoverished mother liquor, and from time to time supplied it with new clean metal, helping it to meet all the demands made upon it by the progressive crystal formation. If this operation were not properly performed, the impoverished mother liquor would be unable to supply sufficient crystals to give a solid compact mass. The result would be either a large cavity or a series of small ones, or a loosely packed mass of large crystals giving a very weak casting.

The feeding of a large and bulky casting was of great importance, for the great length of time taken in cooling down meant a longer period for crystal growth, and, incidentally, a weaker casting. Professor Turner had drawn attention to that in his book on "Iron and Steel," where he said: "It is generally found that the strength of a large casting per unit of area is somewhat less than that of a small one, since the closeness of grain is usually, though not always, associated with increased tenacity." Shop practice proved this to be true; there was a density or hardness that gave the best results. The greatest strength was associated with small crystals which had not arrived at the brittle stage, and it was for the foundrymen to determine what the degree of density was for their own particular work, and having determined that, to be sure that they did not upset it by improper feeding; if feeding was done badly they would add the weakness of cavities to the weakness of large crystals.

An aspect that should be considered in the production of castings was that of design. The draughtsman should know that if anything happened during the cooling to affect the growth of the crystals, or to cause them to take a contrary direction, such action might give rise to a plane of weakness, and that, therefore, it was very important, in large castings where strength was required, that there should be no sharp or recurring angles, as these must certainly lead to planes of great weakness, because the greater mass of metal in those corners would be the last to cool, and the crystals which formed at right angles to the cooling surface would be disturbed by butting up to each other, and a plane of weakness would be the result. That was ably shown by Mr. Fletcher in the Paper mentioned.

It often happened that castings which had passed all the mechanical tests satisfactorily failed when subjected to steam or water pressure. This failure was invariably caused by faulty crystalline formation which might not have happened if the designer had had a more perfect knowledge of the law governing crystallisation. It was of vital importance that designers should understand the problem, so that all lines which affected adversely the crystal flow should be eliminated. Irregularity in design should also be avoided as far as possible, for it was obvious that the thinner metal would be the first to cool, and would draw on the reserve of the still molten section, with the result that either a fracture

would occur or the heavier section would be a spongy and segregated mass unless specially treated.

But after the designer of castings had done all he could to assist, he would not be able to remove all the ills that beset the foundryman. There would still be local heavy sections, thin walls joining up to strong ones, and heavy bosses placed in positions impossible to feed. The foundryman in such cases would be greatly helped by the careful application of chillers or denseners. The changes which took place during the cooling of cast iron were not instantaneous; they were chemical changes and took quite an appreciable time to accomplish. The chiller was thus allowed to have a marked effect, a chiller applied to a heavy section being a much better conductor of heat than the sand of the mould; it carried away the heat from the thick part of the casting much faster than did the sand from the thinner section, thereby giving a more uniform growth. Assuming that the metal used was suitable for the work in hand, the whole question of perfect crystallisation resolved itself into rate of cooling. In a Paper on this subject given by Mr. F. J. Cook were given data of very interesting and convincing experiments personally conducted, showing the effect which chillers or denseners had on the chemical properties of the metal, their effects on the mechanical strength, etc. One interesting experiment of Mr. Cook's had a distinct bearing on their discussion that evening. Mr. Cook said: "It is a well-known fact to metallurgists and foundrymen that the physical properties of most cast metals, such as the size of crystals, hardness, coarseness of grain, strength, etc., are greatly influenced by the rate of cooling from the molten to the solid state, and in none is this more freely shown than with cast iron; in fact, with this metal it must only be considered second to, and in some cases of equal importance to the chemical composition of the metal itself, when considering it on the lines of its tensile strength. To prove this statement by ocular demonstration, I had a bar cast in the shape of a wedge, tapering from ¼ in. by 3 in. at one end to 6 in. square at the other, and 2 ft. long. This was made on end, the thin end at the bottom, in a dry sand mould, and cast from metal fairly low in silicon and total carbon, such as would give strong castings of 1¼ in. to 2 in. thick, and was left in the mould until properly cooled down. When the bar was broken the fracture ranged from close-grained white iron at the thin end to very open grain with large crystals in the centre, giving very little cohesion at the other and with varying degrees of closeness in between. To demonstrate further the difference in various parts of the bar, hardness tests were taken at 5 ins. from the thin end, 3 ins. from the thick end, and halfway between. This hardness was taken by the drill method, the results coming out at 70, 56 and 40 respectively."

If a section similar to that in Mr. Cook's experiment had occurred in a casting, it was obvious that a similar result would be obtained unless the casting were specially treated. The special treatment for a section of that description must be one that would expedite the rate of cooling. Chilling was perhaps the easiest and least laborious method of doing this. Of course, a little experience was necessary to determine the right thickness of densener to be used. Care must be exercised that the densener was not thick enough to cause a chilled surface on the casting, but just thick enough to densify the crystal formation, to give a good wearing surface that was not too hard to machine; a little care in that direction, and the method would prove of real practical value.

The making and fixing of the densener was a very simple matter; if it was a flat surface on which one wished to use it, this presented no difficulty. A pattern could readily be cut to the desired length, width and thickness. If the surface was an irregular one, then, to save the expense of a complicated pattern, a piece of pliable clay should be pressed carefully on the pattern till a good impression had been obtained, then pared to the thickness required, and left on the pattern all night to stiffen, by which means a good pattern for the densener would be obtained. When moulding these chillers or denseners it was good practice to cast a couple of sprigs in the back, or a rod, according to the weight. These would be of assistance in securing the denseners safely in the mould for which they were intended. If they were to be used on the outside of the mould, they should be placed on the pattern and rammed up in the usual way; but if they were to be used in cores it was necessary to be sure that clearances had been allowed so that the densener and the core iron did not butt up together, thereby hindering the normal contraction.

Mr. Howell concluded by drawing attention to what he described as some very interesting pieces of cast iron which embodied all the points to which he had referred. In the second, that which had been more quickly cooled, would be seen a fairly dense and close-grained cast-iron, but on the inside of the thicker part the result of the impoverishment of the mother liquor was to be seen. In the cavities had grown large masses of crystals showing how far the crystal growth would go under such conditions.

Malleable Iron.

Mr. A. Fraser had been asked to deal with the subject from the points of view of foundrymen working in malleable iron and cast steel. Dealing with the use of chillers and feeders in connection with malleable cast iron, he remarked, the main points to be remembered were that this iron had a very high liquid shrinkage, also a narrow range of fluidity, the latter varying considerably with the composition. It also had a high linear contraction which varied very slightly with the composition, as the castings should be of white iron throughout if success was to be attained after heat treatment. Those three features in the cooling of malleable cast iron created for the foundrymen sometimes difficult problems in producing sound and whole castings, and the judicious use of chillers was in many cases the solution of those problems. One of the chief functions of a chiller was to eliminate the local liquid shrinkage cavities which were usually found in the weighty sections of a casting, and which might take the form either of a hollow in the interior of the heavy section or of a depression in its surface. This fault in a casting could be overcome by placing a gate or feeding head on the sections likely to be imperfect in this manner; but where there were a number of such places on the same casting the molten metal and additional work required to procure a sound casting would be excessive, and would not lend itself to economical production. The value of chillers in a case of that kind was obvious, and the service required from them was to cool those sections on which they were placed so rapidly that all liquid shrinkage at those sections should take place before the metal in the gate and the parts of the casting connecting it with the heavy section solidified.

When a casting was being made on which a number of chillers were used, care should be exercised to have them of the proper size and weight, because if the one nearest to the gate or feeding head was too large it would check the feed of molten iron to the parts beyond it and cause cavities or sponginess even in the thin section; also where a number of chillers were used those nearest the gate should not be so small that the flow of iron passing them so raised their temperature before the mould was filled as to impair their efficiency as heat conductors at the time required.

Another fault frequently found in malleable-iron castings which might often be rectified by chilling was called in foundry parlance a "sear." This was a hot crack resulting from linear contraction on adjacent section cast at angles to one another while their junction was still in a semi-rigid state, and had not attained sufficient cohesion to overcome the resistance of the mould to their passage. It usually occurred where the sections were at acute angles to one another, and was found at the apex of the interior angle. In appearance it resembled a hair, varying in thickness, laid irregularly on the casting. The use of chillers to rectify that fault he did not advocate generally, as the addition of a fillet to the pattern usually did all that was necessary, provided the fillet did not result in such an accumulation of heat at that point that liquid shrinkage was encountered.

Another sphere of usefulness for chillers was in the prevention of "flying," or the breaking into pieces of castings during the later stages of their cooling, or while undergoing the annealing process. This was a very common trouble and was the result of the different rates of cooling acting on the times of contraction in the different sections of a casting. The method commonly adopted to relieve the stresses causing those breakages was to transfer the casting while still at a very high temperature into a muffle, and cool very slowly. But occasionally castings could not be transfered to the muffle quickly enough, or the muffle might be out of order. Chillers might then be brought into use to equanse the cooling, and castings might thus be produced quite successfully without the slow cooling.

With regard to the breakage of castings from the cause just dealt with, the results of some experiments might be interesting. A casting was being made regularly and successfully with normal cooling from an iron with a silicon content of 0.45 per cent., and on a test bar the contraction was 0.24 ins. per foot. For certain reasons the iron was changed, one being substituted having 0.8 per cent. silicon, with contraction of 0.22 ins. per ft. This confraction varied slightly from day to day, but the result of the change was that although the castings were made in exactly the same manner, a whole casting could not be obtained from the iron with the lower contraction under the same conditions as formerly. To clear up this seeming incongruity, a few experiments were made, and although nothing conclusive was arrived at, the results showed that the 0.45 per cent. silicon iron had taken 10 to 14 per cent. more of its total contraction than had the iron of 0.8 per cent. silicon when both had cooled to 700 deg. C. This would suggest that there was a considerable freedom of movement among the crystals while the iron was solid, and that yet at a high temperature the crystals were able to adjust themselves to a pull or pressure, little permanent stress being left.

With regard to the preparation of chillers almost every foundryman had his own "best method." There was also a large variety of substances in use as preparatory coatings. Among them were red lead, plumbago, French chalk and mixtures of resin and oils. Some guide as to their preparation might be given. A chiller on which the metal impinged and became at once stationary should be coated only with a substance with a low volatile constituent; otherwise, with a thin-sectioned casting, blowholes or a depression occurred on the surface, and from want of contact the value of the chiller was lost. A chill over which much metal had to flow, or which was subjected to considerable heating before the mould was filled and the metal at rest should be coated with a substance containing a much higher volatile constituent, so that it was protected for some time by a film of gas. On a chiller which was weighty enough to stand up to the work expected from it, a coating of black oxide of iron, formed by heating to a good red colour, had been found to afford sufficient protection. With this coating the chiller must not stand too long and collect moisture, as the red or hydrated oxide was, of course, abhorrent to molten iron. Iron which had a clean metallic surface should not be used for chillers without previous coating because of the danger of cementation to the castings. Grey-iron chillers which got heated up to redness in their work should not be used many times, as, apart from their liability on repeated heatings to increase in volume and become distorted, small fissures containing gas developed in the iron, and with an increase of temperature this gas expanded and frequently caused blowholes.

The placing of chillers was seldom a matter of choice. They must be so placed that their properties would produce the desired effect. But it was a generally accepted fact that more care was required with some positions of the chillers than with others. All chillers, if left standing for some time before casting in green-sand or partially-dried moulds, collected moisture, and if free egress was not allowed a faulty casting was obtained. If a chiller was placed and used with its face in a perpendicular position, or at a gently rising angle, this trouble was almost eliminated, as the metal rising in the mould drove the vapour before it. Horizontally placed chillers, either on the top or on the bottom of the casting, were not quite so trustworthy in their action, as vapour was frequently entrapped at their surfaces, especially in the case of those at the top of the mould. A matter which should be carefully watched when using a local chiller was that the sand and chiller were in perfect contact at their junctions; otherwise the metal would penetrate there, forming an enclosure from which the escape of gas was retarded.

It would be gathered from his remarks that the main function of a local chiller, when applied to counteract faults due to liquid shrinkage, was to so accelerate the rate of cooling at the place of contact that all liquid shrinkage would have passed at that place before the metal had solidified in the adjoining sections which were fed from the gate or feeding head. A chiller did not do away with or decrease the volume of liquid shrinkage in the least, but only changed its position; and if all things about the mould were right, that position should be in the centre of the gate or feeding head.

There were limits to the use of chillers, both economical and practical. Chillers were seldom used on weighty and even-sectioned castings, their value on this class of casting being so small. As an example, suppose a 6-in. cube of malleable iron was cast into a heavy iron mould and covered by a

sand top with a small inlet gate passing through it, the shrinkage in this casting would be nearly as great as if it had been cast into a sand mould, but there would be a slight decrease of this shrinkage (owing to the gate supplying fluid metal until the body of the casting was colder) compared with casting in a sand mould. It was apparent from this that chillers and rapid local cooling would not do what was necessary on weighty sections to secure a good casting. Therefore, feeding heads were brought into use, their function being to supply fluid iron to the casting until the latter had solidified throughout. This meant that on weighty castings of small bulk the feeding heads had to contain at least as much metal as the casting. To reduce this seeming waste of metal in the heads, the method adopted was to curtail the head's supply on first pouring, and afterwards make small additions of metal at a high temperature, so that the relative rates of cooling of the casting and the head were altered.

As he had already mentioned, unequal cooling in conjunction with high linear contraction sometimes created difficulties in the production of malleable castings. As feeding heads were invariably placed at or near the heaviest sections of a casting, the cooling of those already slow cooling places was much more retarded, thereby causing the unequal cooling to be proportionately greater.

The internal stresses set up by this were sometimes very destructive even when all due precautions were taken. The question, therefore, sometimes arose whether it would be better to chill the heavy sections of a casting and thereby ensure more equal cooling, and consequently the use of less molten metal, and with probably a little additional labour, or to use feeding heads on the casting with the danger of more internal stresses, the use of more molten iron, and with probably a little less labour expended to produce the casting. This question only the man on the spot could answer, as muffling facilities, supply of molten metal, and other points had to be considered.

(To be continued.)

Acid *v.* Basic Steel for Castings.

In a Paper read before the American Foundrymen's Association, MR. EDWIN F. CONE, of "The Iron Age," New York, discusses open-hearth steel. He describes an interesting method of avoiding slag contamination in the manufacture of basic steel, remarks upon the effect of oxygen, and describes a method of producing basic castings from acid scrap. He points out that to overcome a low silicon content in the last stages of a basic heat it is customary often to start with a high initial silicon, perhaps 0.40 to 0.45 per cent., especially where considerable time must elapse in pouring the heat. But even then, a basic slag being more highly oxidised than an acid slag, the metal at the end of the operation is more highly charged with oxygen, tending to less sound steel. The average basic heat will analyse lower in silicon at the end than at the beginning of the pour, often by 50 per cent.

The author states that only one really effectual means of avoiding slag contamination has been accomplished. This consists in tapping a heat through one ladle into another, leaving the slag in the first ladle. By tapping the metal from the furnace into a ladle containing a nozzle and stopper about 6 in. in diameter, and then bottom-pouring the metal into a second ladle, all the slag can be retained in the first ladle. Such a method is claimed to be effectual in overcoming the slag contamination, but to carry it out the steel must of course be run excessively hot in order to undergo this transfer and still be suitable to avoid misruns. In addition the metal is not benefited but rather injured by being made excessively hot. The furnaces also are injured more quickly and the fuel cost is higher, so that the cost of the furnace repairs and the additional ladle make the practice virtually prohibitive.

To what extent oxygen in steel is harmful is not definitely decided. Basic open-hearth steel, other things being equal, is of necessity the more highly oxidised one. The reactions and conditions involved cause this. In commercial steel castings this question is not an important one, as many basic castings are used sucessfully under conditions necessitating the withstanding of severe shocks. It is, however, a fact that more manganese is necessary as a neutraliser of this more highly oxidised condition than is the case in acid steel. The manganese consumption is therefore higher, as is also the silicon, for reasons previously stated. But in electric steel castings, even from a basic bottom, the manganese consumption is decidedly lower than with the acid or basic open-hearth. This shows the healthy condition of the steel, especially as to its oxygen content. From one-third to one-half as much manganese is necessary in electric practice as in the open-hearth to achieve the same results.

In normal times basic steel is considered less expensive to make because of cheaper pig-iron and scrap. But these are more or less offset by the greater cost of the furnace lining and lime additions necessary. The result of the refining action of the basic furnace is a steel purer in respect to phosphorus and sulphur than is the acid steel. It is doubtful whether this alone is a particular advantage. The harmful effect of phosphorus and of sulphur in particular within limits has been exaggerated, and it is not likely that this difference alone confers any special merit on basic steel. Electric steel can be made so low in these two elements as to be considered by some a disadvantage.

Describing a method of making basic castings from acid scrap, the author states that the process is being practised successfully by a large foundry in the States. Acid quality scrap is used on a basic bottom. The only difference between the procedure at this foundry and at regular acid foundries is that they buy the same scrap that the acid producers use and a grade of pig-iron similar in every way except its silicon content. The operation in other respects is the same as regular basic practice. Less lime by 50 per cent. is used or necessary. The additions are made as in usual basic practice.

The author concludes that with rapid advances in metallurgical practice it is not unlikely that a way will be found whereby basic may become equally interchangeable with acid steel castings. To what extent electric steel castings may affect this question is important. As bearing on this, it is interesting to note that of the total steel casting output of the United States in 1909, only 0.05 per cent. was electric steel. In 1915, electric steel castings comprised 2.6 per cent. of the total and the output has only begun to grow.

MESSRS. J. HANSON and H. S. HALL, lock manufacturers and brassfounders, 56, Charlotte Street, Birmingham, trading as Hanson & Hall, have dissolved partnership.

The Development of the Manufacture of Steel Castings.*

By Ernest F. Lange.

This Paper falls naturally into two parts, according to the chronological and technical sequence of the processes, as follows:—Part I., The Crucible and Bessemer Steel Processes; Part II., The Open-Hearth and Electric Steel Processes.

I.—Crucible Steel Processes.

It is an interesting fact that all the metallurgical processes involved in the making of steel have been evolved step by step, each founded upon some preceding process and, in its turn, giving birth to further developments, each step being marked by immense labour and patient research. To no series of inventions can Edison's dictum that "Genius is 2 per cent. inspiration and 98 per cent. perspiration" be more fittingly applied.

Huntsman's method, modified by Heath's process of adding manganese, is the prevalent one in Sheffield for the best cutlery and tool steels. In 1908 the author was informed by Mr. Osborn that the output of crucible steel in Sheffield amounted to 1,000 tons weekly.

For steel castings, the carburising-fusion method, in which the percentage of carbon in the product is regulated by the addition of charcoal, is the prevalent one. Some typical mixtures are made up in the proportion of one-third of soft scrap, one-third medium scrap, and one-third of hard scrap. The amount of charcoal added is increased with each fusion. Ferro-manganese alone or ferro-manganese and spiegel are finally added. Other typical mixtures are made up of Bessemer scrap and hematite, silicon and manganese being also added and a little aluminium before teeming. The crucibles used are either of graphite or of fire-clay; in this country almost invariably the latter. The ordinary type of Sheffield pot-hole furnace is too well known to need description. In the United States and on the Continent the Siemens regenerative gas-fired furace is largely used. These furnaces are expensive to build but economical in use. Three tons of coal-slack, gas-fired in the producer, will melt as much steel as seven tons of coke in the ordinary direct-fired shaft furnace.

Gas furnaces have not made much headway in Sheffield, it being alleged that the heating is not so uniform as in the ordinary pot-holes. It may be suspected, however, that the conservatism of the workers is the real reason for this. Some later adaptations of the Siemens principle are doing good service, notably the Dawson-Robinson-Pope furnace at Messrs. Jessop & Sons, Sheffield, and the "New-Form" Siemens furnace as working at the Sheffield University.

About twenty-five to thirty years ago, a great deal was heard about "Mitis" steel castings. This process was principally developed in the United States. In the process Nobel's petroleum furnace was used. This was an oil-fired furnace comprising two or three chambers, each containing a pair of crucibles. For the softest castings the charges consisted of wrought-iron scrap only; for harder castings steel scrap and cast iron were mixed with the wrought iron. When the contents of the two crucibles nearest the flame were fused, sufficient 8 per cent. ferro-aluminium was added to introduce from 0.05 to 0.10 per cent. of aluminium, and a few minutes later the crucibles were teemed. The two crucibles from the farther chamber were then transferred to the hottest chamber, their places being taken by freshly-charged crucibles. The process was interesting by reason of the fact that it made known the wonderful quietening power of aluminium in steel, and the use of aluminium as a deoxidiser of steel spread into every branch of steel-making. The "Mitis" process started many other crucible processes for making soft steel castings, largely for replacing malleable cast iron. Furnaces capable of holding several crucibles were designed for working at the highest temperatures. These enabled the production of sound low-carbon castings, which were put on the market without being annealed.

At the Mild Steel Castings Company's works at Hay Mills, near Birmingham, there are ten four-pot furnaces, each furnace having a total melting capacity of 300 lbs. of mild steel. Each pair of furnaces is equipped with a Keith-Blackman 10-in. fan, direct motor-driven, and taking approximately 1½ h.p. The blast pressure is up to 4 in. of water when melting mild steel. The melting of mild steel is accompished in about two hours with a consumption of about 1½ cwt. of coke to 1 cwt. of metal. The castings are made in green sand, and are not annealed. They can be case-hardened, and are also weldable by the oxy-acetylene process.

The largest crucible-steel foundry in the world is that of Messrs. Krupp, in Essen. There are no less than 23 large crucible furnaces, each holding 100 crucibles of from 50 to 55 kilos. capacity (=110 to 121 lbs.). The furnaces are arranged in two rows, one on each side of the shop, and their construction is very different from the type of Siemens gas-reversing crucible-steel melting furnaces usually met with. Instead of the furnaces being below ground, with the heating chambers in a long and narrow formation, they are above ground, the hearths being about 2 ft. 6 in. from the floor line in height, and the heating chambers shaped not unlike those used for annealing at Horwich and Crewe. The crucibles are placed in ten rows of ten each, with but little room between them, and thus occupy the whole space of the hearth.

The author was fortunate in seeing there the casting of an ingot of 60 tons for a large armour plate.

This was done as follows:—The massive ingot mould, sunk below floor level in the middle of the shop, and which had been previously heated to a red heat, had two vertical runners connecting with the bottom of the mould, and projecting slightly above the level of the floor. Into these projected the ends of two long inclined ganister-lined gutters. A couple of minutes before the opening of the furnaces the foreman gave a signal at which various teeming gangs took up their position by the pullers out. At a further signal each furnace door ascended and the puller out, working a pair of suspended tongs, pulled out the crucibles in their order, passing them to the carriers who, after first cooling the crucible bottoms in a steam jet placed on the floor by the side of the furnace, took them

* From a Paper read January 13, before the Manchester Association of Engineers.

and teemed them into the ganister-lined gutter aforesaid. This being carried on altogether in a definite unbroken and systematic order, an ever-flowing stream of molten metal poured from two sides into the mould until the last crucibles were emptied. There was no hitch nor hurry, and the whole of the work of teeming was executed with discipline and smartness military in its character. The crucibles used are graphite and are only used once. They are made up of about 50 per cent. graphite and about as much "chamotte" (ground burnt clay pots) with a little pot clay.

The gas producers at Krupps are in the form of chambers sunk below ground level, and, with some modifications, are essentially Siemens producers arranged in groups. The stacks are fitted with an elaborate system of cooling and tar deposit tubes, and the air blast for the grate is worked by steam injectors. The tar is used for the "basic" steel process.

Bessemer Steel Processes.

The author now comes to deal with steel castings made from steel produced by the pneumatic process in either a bottom-blown or a side-blown converter. The excellent work done with the old Swedish fixed converter with low-pressure blast remained in men's minds, and as the Bessemer converter gradually developed into a steel-making apparatus for great outputs, there were not wanting inventors who thought by improvements on the old discarded type to fit the same for producing steel ingots on a small scale. The fixed converters were cheap to build, no tilting mechanism was required, and a small blast pressure sufficed. In such way history repeats itself. In 1886 Sir Henry Bessemer publicly drew attention to this want of novelty, but without taking further action.

A number of such converter installations were put down, the principal inventors being Clapp and Griffiths and Witherow in America, and Hatton in this country. These improved fixed converters had slag-spouts and removable bottoms, and means for controlling the blast at the tuyeres. These converters were all successful in producing good steel, but at the cost of a great waste of iron. In practice, many other drawbacks revealed themselves. It was not possible to repair a tuyere or take a sample during the blow. Re-carburisers and scrap could not be added into the converter.

Now, it happened that one of the first Clapp-Griffiths converters in Europe was put up at Stenay, by M. Walrand, a consulting engineer in Paris, and formerly at the Creusôt works. The Stenay works comprised a small rolling mill and foundry, Société des Laminoirs et Fonderies de Stenay, Meuse, by name, the product of the converter being intended not only for the production of soft ingots, but for steel castings as well. The objections to the fixed converter above enumerated proved so fatal to the production of steel for castings, that M. Walrand schemed a tilting converter in place of the same, and with the tuyeres on one side of the internal diameter only. This converter, known as the Walrand-Delattre converter, and which proved a success, was the pioneer of the present-day tilting small side-blown converters, as the following will show. The success of this converter led M. Robert, the then manager at Stenay, to endeavour to improve it. The improvement which, however, only appeared as such in the mind of M. Robert, was to give a plane form to that part of the inner wall in which the tuyeres lay.

An arrangement was eventually come to between Walrand and Robert, but the converter hereafter bore the name of the Robert converter. During the four years following, Robert patented various trifling details of construction. The small side-blown systems were thus supplemented by the Robert system, and in 1889 the use of such plants was in its zenith, but from that date the manufacture of ingots from side-blown converters steadily declined, and now they are to be found in only a few places where local circumstances keep them out of reach of the competition of the large steel works. This fall of the side-blown converter for ingots was accurately foretold by far-seeing men at that time, who recognised that the circumstances which had called them into being were only transient, and that the progress of the large Bessemer and Siemens works, both for acid and basic material, would eventually render the product of such small side-blown converters too costly.

To continue our history. In the year 1888 the firm of Bergés, in Paris, erected a steel castings foundry for the Robert process, under the direction of its engineer, M. Tropenas. The beginning was hard, owing to bad business times; indeed, so hard that this firm gave up the undertaking, and the Stenay Company took over the same and started it afresh under the name of Société des Fers et Aciers Robert.

Meanwhile, the experience which M. Tropenas, who was both a clever draughtsman and metallurgist, had obtained with the Robert converter was sufficient to reveal to him how to improve upon it. In 1891 M. Tropenas, who had retired from the Paris firm, came to Sheffield to help Messrs. Edgar Allen & Company in some experiments they were making with a small Robert converter. These not being very successful, they arranged with M. Tropenas to construct a new converter according to his designs and for his method of working. The new converter proved a great success, so much so, that Edgar Allen & Company decided to make all their steel for castings by this process, and they secured the entire patent rights for Great Britain. The new converter was also set to work on the Continent, and met with equal success; of all the small converter systems used to-day for the manufacture of steel for castings, the most extensively used is the Tropenas system.

In the Tropenas converter we have a vessel which very closely resembles the Robert. Whereas, however, Robert pre-supposes great advantages to result from a rotary motion of the bath, Tropenas will, as nearly as possible, prevent any motion of the bath of metal and, to this end, places the tuyeres symmetrically and gives considerable depth to the bath by shaping the converter-bottom in the form of a truncated cone. The important part of the Tropenas patent lies in the means employed for raising the heat of the converter, and both directly and indirectly that of the metal. About 6 in. above the chief blowing tuyeres a parallel line of lesser tuyeres enters the converter; these lead from a blast-box which is connected by a pipe, fitted with a stopcock, to the blast-box of the chief tuyeres. About the beginning of the boil, when CO in considerable quantities has begun to be evolved, communication is opened between the lower and the upper blast-boxes, and the blast then emerging from the upper or secondary tuyeres gives oxygen to the CO, which burns to CO_2 with the evolution of much heat, enabling an excess of temperature to be maintained during the second half of the blow and at the cost of less consumption of iron than would otherwise be the case.

The patent extends also to the deviation of a portion of the converter gases through an opening at the side of the neck of the converter, thence

through a brick-lined passage, and the hollow trunnion and standard into a set of reversing recuperative chambers, by means of which it was proposed to heat the incoming air and thus further to increase the temperature of the operation. The first Tropenas converter had this arrangement fitted, but it was disused after a while as it was found, firstly, that they obtained a hot enough operation without it, and secondly, the immense amount of dust in the converter gases, and the heating of the trunnion, caused practical difficulties which are almost too obvious to mention.

The second row of tuyeres has now been abandoned, as prolonged experience has shown that the same effect can be just as well obtained by varying the blowing angle of the converter and regulating the blast pressure.

The most notable exception to the almost universal use of the side-blown converter for converter castings is the employment of bottom-blown vessels by Hadfields, in Sheffield. No particulars of their process have been made known, but they have built up a highly prosperous and successful steel-foundry business by its means.

In 1894 the late George J. Snelus, F.R.S., and the author investigated a successful process for making steel castings from steel blown in very small bottom-blown converters. This was known as the Walrand-Legénisel process, and consisted in simply adding to the metal, at the end of the ordinary blow, a quantity of ferro-silicon, usually from 5 per cent. to 10 per cent. of the weight of metal in the converter, and then blowing again for a short period, producing an afterblow during which a large amount of heat is generated by rapid combustion of the silicon. Some 200 deg. C. of superheat was easily produced by this process.

The "Stock" Oil-Fired Converter.

The author devoted the concluding portion of his Paper to an account of the "Stock" oil-fired converter an illustrated description of which has already been published in our columns. He submitted the following particulars of the "blows" made on the occasion of a visit of inspection he paid to the plant at Darlington Forge in 1912.

Particulars of Casts, February 13, 1912.

No. of charge	G. 1706.	G. 1707.	G 1708.	G. 1709.
Lit up	6.15 a.m.	—	—	2.0 p.m.
Charged	7.11 a.m	9.18 a.m.	11.15 a.m.	2.23 p.m.
Weight of charge(cwt.)	37 hematite 3 scrap	37 hematite 4 scrap	37 hematite 4 scrap	37 hematite 4 scrap
Melted	8.39 a.m.	10.39 a.m.	12.43 p.m.	3.45 p.m.
Oil used in gallons	Heating, 31 Melting, 55	Melting, 52	Melting, 52	Heating, 8 Melting, 51
Blow started	8.40½	10.40	12.45	3.47
Blow finished	8.55	10.55	1.0½	4.3
Weight of final mixings	1¼ cwt.	1¼ cwt.	1¼ cwt	1¼ cwt.
Elect. power, units	18 48	45	51	54
Temp. of blast	170°	200°	220°	210°
Final carbon content	0.25%	0.24%	0.24%	0.24%
Remarks	30 lbs. of glass added to slag towards finish	do.	do.	do.
	T. c. q.	T. c. q.	T. c. q. lb.	T. c. q.
Steel in ladle	1 16 2	1 18 0	1 17 3 14	1 18 0
Percentage loss	12.4%	10.6%	10.9%	10.5%

Total output of steel for the day, 7 tons 10 cwts. 1 qr. 14 lbs.
Total consumption of oil 249 gallons.
Consumption of oil per ton of steel, 33.2 gallons.

The author remarked that he was able to note the appearance of the carbon lines in the flame in the second period of the blow by means of a handy pocket spectroscope, and could note their disappearance, which was simultaneous with the turning down of the converter on the dropping of the flame, as noted by the operator's practised eye, thus shewing that the operation lends itself well to a simple method of control that can be used by anyone just starting in the manufacture of steel by this process. After the final additions were put in, the steel was rabbled, and after that lay as quiet as any open-hearth steel. The steel was then poured into a ladle suspended from the overhead crane hook with an interposed Dennison's weigher, by means of which the exact weight of steel produced was known, and the corresponding loss of conversion was made manifest.

In no country has the small converter process for the manufacture of steel castings had a greater development than in Belgium. There are, at first glance, no obvious reasons why this should be so, but the fact remains that before the war the Belgian foundries were able to import hematite from this country, to convert the same into steel castings, and to undersell the British foundries in their own markets. The freight cost of the material, both ways, constituted already a handicap of 30s. a ton.

By the kindness of Baron de Laveleye, the author obtained from the Comptoir des Aciéries Belges, in Brussels, the following figures regarding the production and value of steel castings manufactured in Belgium, dating from the year 1900, there being no earlier statistics available :—

Year.	Production in metric tons.	Value in francs.	Year.	Production in metric tons.	Value in francs.
1900	17,082	7,541,000	1907	54,900	19,393,150
1901	14,060	5,377,950	1908	51,620	17,781,150
1902	17,940	5,287,300	1909	52,040	16,161,050
1903	18,930	6,041,050	1910	52,660	15,937,400
1904	24,900	6,872,800	1911	64,460	20,562,000
1905	26,680	7,428,750	1912	72,630	23,588,500
1906	45,720	14,728,630			

It will be seen that in those twelve years the manufacture of steel castings in Belgium more than quadrupled itself. Later, in connection with the above figures, the author asked Baron de Laveleye the following questions :—

(1) Are the prices fixed by a syndicate, or are the different firms independent?

(2) Are the steel moulders in Belgium paid, as a rule, by time or piecework?

(3) What proportion of the steel castings in Belgium is made by the small converter process?

(4) What proportion of the steel casting outputs given is exported?

He received, in due course, the following replies :—

(1) There is no syndicate for steel castings; the price is therefore the price of an open market.

(2) Nearly all the men are paid by piecework, practically *none* by day work.

(3) Practically all the steel castings are made by the *small converter* process.

(4) About 50 per cent. is exported directly by the producers, but perhaps another 20 or 25 per cent. is exported as parts of locomotives or other engines, rolling stock, etc., but by Belgian building shops.

It will thus be seen that the Belgian steel industry was entirely independent and self-supporting. This economic fact conveys a useful lesson. It is to Belgium's credit that she could supply it. In spite of the low prices of the Belgian steel castings, all the Belgian foundries were said to be making money. They even exported electric castings into Germany, in spite of freight and tariff which amounted to 7s. per 100 kg. per 5,000-kg. load.

Ministry of Munitions Takes over Copper Stocks.

The following notice has been issued under date of January 1, 1917 :—

The Minister of Munitions, in exercise of the powers conferred upon him by the Defence of the Realm (Consolidation) Act, 1914, the Defence of the Realm (Amendment) No. 2 Act, 1915, the Defence of the Realm (Consolidation) Regulations, 1914, and all other powers thereunto enabling him, gives notice and orders as follows :—

(1) He hereby takes possession as from the date hereof until further notice, upon the terms specified in the Schedule hereto, of all unwrought copper, including copper scrap and swarf, in any form whatsoever, subject to the following exceptions :—(*a*) Rough copper, copper ore and copper scrap and swarf in the possession of or due under an existing contract in writing for future delivery to a smelter or refiner for the purpose of conversion into refined metal. (*b*) All copper, including copper scrap and swarf, in the possession of or due under an existing contract in writing for future delivery to a manufacturer for use in such manufacturer's own works. (*c*) Copper scrap and swarf especially excepted under the written authority of the Minister of Munitions.

(2) If any person having control of any metal to which this notice applies without the consent of the Minister of Munitions sells, removes or secretes it, or deals with it in any way contrary to any conditions imposed in any licence or permit that may have been granted in respect thereof, he will be guilty of an offence against the Defence of the Realm (Consolidation) Regulations, 1914.

(3) All existing licences issued by or on behalf of the Minister of Munitions for dealing in any scrap or swarf to which this notice applies are hereby cancelled.

(4) The Minister of Munitions hereby requires every smelter or refiner to make a return to the Director of Materials at the end of each calendar month, including the month of December, 1916, of the total quantities of refined copper of each description in stock, distinguishing between (1) that sold for use on Class "A" or Class "B" work, (2) that allocated for such use in his own works, and (3) the residue not so sold or allocated, and he further requires every maker and holder of copper scrap or swarf to make a return to the Director of Materials at the end of each calender month, including the month of December, 1916, of the total quantities of each class of such scrap or swarf in stock, distinguishing between (1) that sold for use on Class "A" or Class "B" work, (2) that allocated for such use in his own works, and (3) the residue not so sold or allocated.

(5) All applications with regard to this Order should be addressed to :—

The Director of Materials, A.M.2 B.,
Armament Buildings,
Whitehall Place, London, S.W.

and marked "Copper Permit."

Copy of Schedule.

The Schedule above referred to is as follows :—

(*a*) Copper included in the returns made in accordance with Clause (2) Sections (*a*) (*b*) and (*c*) of the Order made on December 8, 1916, and taken over under the above Order (except copper due for future delivery on sliding scale terms) will be paid for on delivery by the Minister of Munitions on the basis of the value as indicated by the average of the official quotations of the London Metal Exchange for the last fifteen days of December, 1916.

Copper due for future delivery on sliding scale terms will be paid for at not more than 10s. per ton of metal over the original full contract terms, including all discounts, commissions, or rebates of any sort.

Special circumstances in connection with any copper taken over may be taken into consideration by the Minister.

(*b*) A price schedule for copper scrap and swarf based downwards on the quotation for electrolytic copper as a standard will be drawn up by the Director of Materials for the purpose of the taking over of stocks under the above Order, and as a basis for future transactions.

(*c*) The quantities of refined copper specified in the returns of smelters or refiners under Clause (4) of the above Order, and not sold or allocated as therein mentioned, will be paid for on delivery by the Minister at the average of the relative official quotations of the London Metal Exchange for the month in question.

(*d*) The scrap and swarf specified in the returns by makers and holders under Clause (4) of the above Order, and not sold or allocated as therein mentioned, will be paid for on delivery as may be directed by the Minister on the basis of the average of the quotations for electrolytic copper for the month in question, subject to any adjustments for quality that may be necessary.

(*e*) In all cases where two prices are quoted for the same description of copper by the London Metal Exchange, the price paid by the Minister, if based thereon, will be the mean of the two prices, and all prices paid by the Minister will be net per ton delivered c.i.f. United Kingdom port, if imported from abroad, or free on rail at the producer's works if made in England, or equal thereto.

War Service Badges.

The Ministry of Munitions learns that, with regard to the instruction contained in the circular letter (M.M.100), giving notice of withdrawal of war service badges and certificates from all semi-skilled and unskilled men, many firms have not yet complied with the requirements in paragraph 3 thereof, viz. :—

"... under Section 11 of the Munitions of War Act, 1915, to make a return in triplicate of all men in your employ and shown on your register M.M.37/B or D.R.17, as the case may be, on the first day of December, 1916, as *unskilled*, of 30 and upwards (on Form No. 82/K), or *semi-skilled* of all ages (on Form No. M.M.82/H). The copies of such return must be addressed to the Divisional Officer, Board of Trade, of your district. . . . ."

The Ministry of Munitions accordingly desires to give warning that any firms which have not yet made full returns on Forms MM.82-H and M.M.82-K to the divisional officer of the district in which their works are situate, and do not immediately comply with the instruction in question, will be considered by the Department to have failed to comply with a requirement of the Minister of Munitions, and will expose themselves to prosecution in the terms of Section 11 of the Munitions of War Act, 1915.

THE adjudication and receiving order made against Mr. T. W. Jones, metal merchant, 5 and 6, Royal Metal Exchange, Swansea, has been rescinded, the debts having been paid in full.

Cores.

Before a meeting of the Scottish Branch of the British Foundrymen's Association on January 13, Mr. Matthew Riddell in the chair, Mr. Arthur Naylor read a Paper on "Cores: Materials and Comparative Costs." Mr. Naylor remarked that it is now considered an established practice to separate coremaking from the trade of moulding, and very few foundries are now to be found where there is not a coremaking department. This is not only a more economical arrangement, but it is a method from which greater efficiency is obtained. The question of materials used in coremaking varies to some extent with local conditions, The price charged for carriage of new sand has also an important bearing upon the subject, in determining the proportion of new and old sand to be used.

A core should possess the following properties: It should be highly refractory, strong, porous, impervious to moisture, give a clean and smooth skin, and be easily removed from the cold casting. Belfast sand and other sands of a similar nature are not suitable for cores, owing to the fineness of their texture; such sands are more suitable for moulding sands. Yellow rock sand, easily procurable in the West of Scotland, serves admirably for small cores, owing to its toughness; it has also the advantage that it requires no milling before being used. Some difficulty is experienced with this type of sand, in removing the cores from the casting, but this objection is relieved to some extent by the addition of two shovelfuls of ordinary black sand to one barrowful of yellow rock sand.

Another sand, found locally, is of a fine texture and, used as a parting sand, is very suitable for small cores and small cylindrical machine-made cores. This sand is mixed with linseed oil in the proportion of one pint of oil to four shovelfuls of sand, and with sufficient water to bring it to the working consistency of a green sand.

Fine sharp sand, high in silica, obtained in the Clyde districts, forms a good strong core when bonded with oil; this sand has an open texture, allowing ample provision for the escape of the air and gases generated at the time of casting. It has the further advantage of leaving the casting readily, an advantage common to all oil-bonded cores.

With inexperienced foundrymen, the question of comparative costs with regard to ordinary sand cores and oil-bonded cores is a debatable matter. At a first glance it seems a costly procedure to use oil at 35s. to 40s. per cwt. compared with using ordinary sand. However, as a result of actual practice there is no doubt that the use of oil-bonded cores is more economical. For ordinary work, sea sand bonded with linseed oil serves admirably for cores. It is not always advantageous to use oil-bonded cores in every instance, but for work such as steam-chest cores, cylinder-port cores, cores for water-jacketed cylinders, compressors, etc., and in all cases where the extraction of the core after casting presents a difficulty, nothing could be more suitable or more economical than oil-bonded cores.

The amount saved in dressing such castings more than pays for the oil, and any extra work involved in the production of the cores. In the majority of cases an oil-bonded core does not take any longer to produce than a similar core made in ordinary sand; it has also these further advantages, that fewer core irons are required and less venting is necessary than with similar cores in ordinary sand. The question of drying is slightly against the oil-bonded core, but a little experience soon overcomes any difficulty met with in this respect. The temperature of the stove for drying such cores should not exceed 500 deg. Fahrenheit. Oil-bonded cores are much easier to handle and less liable to break when placing in position, and they may be left any length of time in the mould before casting, as they do not absorb moisture.

The lecturer gave an example from his own personal experience to show the comparative costs of the two systems of producing cores. The example selected was the cores of a water-cooled gas-engine cylinder. At first these cores were produced in the ordinary way by grinding a quantity of loam taken from a used mould; this powder was again dried in the stove and then milled with an equal proportion of new sand, and a liberal proportion of horse-dung and clay-water. The production of these cores, including the necessary core irons, took from four to five days, and after the castings were made it took 1½ to 2 days to remove the cores. When the system of oil-bonded cores was adopted the cores were extracted from the castings in 15 minutes. The cost of each system is shown in the following tables:—

Ordinary Sand Cores.

	£	s.	d.
Sand and mixing	0	3	0
Core irons	0	15	0
Making cores	2	5	0
Dressing and blackwashing cores	0	10	0
Dressing castings	1	0	0
Total	4	13	0

Oil-bonded Cores.

	£	s.	d.
Sand and mixing	0	3	0
2 gallons oil at 4s. per gallon	0	8	0
Making cores	1	10	0
Dressing and blackwashing cores	0	10	0
Dressing casting	0	7	6
Total	2	18	6

The core irons for oil-bonded cores, where these are necessary, may be wrought iron, and re-used from time to time; the ends of these irons should be arranged to project into the print of the core, and when this precaution is observed the irons can be easily removed from the casting. Any vertical recesses left by the removal of loose pieces in the core-box should be filled with dry or wet parting sand, and removed after the core is dried. Should these recesses be in a horizontal position the spaces must be formed by rubbing down a small piece of dried core to the shape of the recess; this should be covered with paper and rammed up with the core, the paper forming a parting substance, to facilitate the withdrawal of the small core after the main core has been dried.

If any part of the main core is to come into contact with the plate for supporting the core while drying, the part coming in contact should be separated by a piece of paper, otherwise it may adhere to the plate.

Should any sharp edges be exposed to the heat they are liable to burn. This may be avoided by spreading a little oil from an ordinary oil-can over the exposed part. Oil-bonded cores contract about one-eighth of an inch per foot, and provision for this has to be made in the core-box.

Scabbing is practically an unknown factor with oil-bonded cores, provided a clean open silica sand is used. The boxes in which the cores are made should be well oiled to prevent the sand adhering to the sides of the box.

The Electric Furnace in the Foundry.*

By Eugene B. Clark.

The principal advantage of the electric-furnace method of steel production is the high quality of the steel which it is possible to produce. Thorough refinement is possible. The cost of installation is high per ton of daily output. The cost of operation under average conditions approximates closely to the cost of operating the open hearth or the converter. If favourable operating costs are to be obtained, the electric furnace is less flexible than the converter. It should be operated continuously in order to secure low costs, and continuous operation of the electric furnace may not fit in nicely with the requirements of the foundry.

Notwithstanding these disadvantages, the use of the electric furnace has grown rapidly in recent years. This has been due partly to the demand for a high grade of metal and partly to the desire on the part of foundries whose business is increasing to test the electric furnace. Probably the principal reason for the rapid increase in the number of electric-furnace installations, however, is the enthusiastic activity of men engaged in the development and sale of electric furnaces and the desire of the progressive foundryman to be as well equipped as his competitor. One furnace installation has led to others in many cases. This may seem like robbing the electric furnace of the credit for developing on its own merit, though it is not so intended. I wish to be clearly understood as not speaking in a manner at all derogatory to the electric furnace, and yet I feel that so much enthusiasm has been displayed in presenting its advantages that a word of conservatism and caution will not be out of place.

A belief hastily arrived at that the electric furnace is a cure for all the evils and troubles in the foundry will inevitably lead to disappointment. The electric furnace has some marked advantages, and it also has some annoying disadvantages. A foundryman contemplating the installation of an electric furnace should clearly understand both its advantages and its disadvantages. If he wants to produce an extremely high grade of molten metal and has a market for a product which will require this highly-refined steel, then he has a very strong argument for the installation of an electric furnace. Many electric furnaces have been installed, however, where such conditions have not existed. It should be understood that all the metal which goes through an electric furnace is not necessarily of a high grade. While it is possible to produce high-grade metal, it is by no means true that the furnace itself will produce such metal unless it be operated properly.

The average steel foundry in the past has not been equipped and organised to produce highly satisfactory results from a metallurgical standpoint. The foundryman uses steel merely as an incident in his business. The older methods of producing steel have been to a large extent "rule of thumb." The operation of an electric furnace can be reduced to routine practice with satisfactory results, but this will not be accomplished without the serious effort of a skilled metallurgical management. It is not possible for the average foundry to buy an electric furnace, set it up and start it like a moulding machine. The finer the apparatus, the more skilfully must it be operated to attain to excellency of results.

The very fact that an intending user of an electric furnace will be confronted right at the start with an embarrassing number of different types of furnaces which he may install, each one of which goes by the name of the man who was interested in its development, is evidence of the great variety of ideas and opinions of different men as to what style and type of electric furnace is best. The intending purchaser must decide between not only an arc or an induction furnace, and between various types of each, but, having decided on the general type, he then is confronted by the necessity of selecting a Héroult, a Stassano, a Girod, a Snyder, a Gronwall, a Rodenhauser, a Rennerfelt, or one of a number of others. Such a list certainly is confusing; they cannot all be the best.

If the true advantage of the electric furnace is to be realised, the melting operation is merely the preliminary one. After that a metallurgical treatment of the molten bath is to be accomplished. This is done by the proper manipulation of slags. It is at this point that skill and metallurgical knowledge is necessary. Inasmuch as high-grade steels must be lower in phosphorus and sulphur than the average scrap available for charging, it is necessary, generally speaking, to build the electric furnace with a basic lining. The heat supplied electrically is in such intense and concentrated form and the restricted size of the furnace brings the walls in such close proximity to the arc that delicate regulation is necessary to introduce the heat into the metal without at the same time scorifying the roof, walls and banks of the furnace. This situation is further complicated by the fact that the highly basic slag required for proper refinement is such a poor conductor of heat. Also, when the furnace lining is attacked the composition of the slag is immediately altered and the metallurgical reactions seriously interrupted. When the proper reducing conditions are obtained during the refining period, the copious white fumes which fill the furnace make it difficult for the melter to watch the brick work and to know when a fluxing temperature has been reached.

The absence of a flame, with attendant excess of air, in the electric furnace, while making possible the attainment of conditions peculiar to electric refining, and while in many ways a highly desirable feature, will not of itself ensure deoxidised metal. The bath in an electric furnace is as much oxidised as any open-hearth heat—in fact, dephosphorisation absolutely requires an over-oxidised bath. Successful refining, to be thoroughly done, requires the complete removal of the first slag and the making of a second slag under the action of which the metal is to be thoroughly deoxidised and desulphurised. The proper manipulation of these slags must be in the hands of a man who knows what he wants to do and how to do it. In other words, he must have metallurgical knowledge. The chemical reactions are simple and easily understood, but they are accomplished under conditions

* Read before the American Foundrymen's Association, September, 1916.

which are not easily controllable except under the guidance of skilled operators.

Finally, the question of cost must always be borne in mind. It is easy to destroy or seriously damage the lining of a furnace in the efforts to control a refractory heat and bring it out of the furnace as high-grade steel. At best, the life of roof and walls is short, compared to that of the open hearth, and the small tonnage produced necessarily means high repair cost per ton of steel. In unskilled hands, the electric furnace is likely to prove a source of disappointment in its performance, but when perfection of practice is reached the electric furnace will produce metal of the highest quality. If such a grade of steel is required, and *if it can be used profitably*, the electric furnace will amply repay its difficulties of operation. I have no hesitation in saying that if a foundryman requires a better steel than can be produced readily by other processes, and if he is willing to provide the skilled operating management necessary to provide such steel, he can install an electric furnace with the assurance that he has the best piece of metallurgical apparatus available.

Electric Furnace Practice in the Manufacture of Steel Castings.

In a Paper read before the American Foundrymen's Association, MR. T. S. QUINN describes the operation of a 1-ton Héroult furnace with a transformer capacity of only 225 k.v.a. and a 2-ton furnace with 600 k.v.a. capacity. The product of both furnaces is small steel castings, averaging 5 to 10 lbs. in weight. The data given cover the 1-ton furnace only.

From March, 1915, to August 1, 1916, the furnace made more than 2,000 heats on the original basic bottom. In that time it has not been out of service except for relining, which it was customary to do on a Saturday or Sunday. The magnesite bottom, which was set in layers of 1 in. to 1½ in., is still in the furnace. In setting a bottom in this fashion a monolithic mass is obtained that cannot be equalled by a bottom rammed in with magnesite, tar and pitch. The life of a lining varies from 100 to 125 heats, and the life of a roof from 125 to 150 heats.

Amorphous-carbon electrodes are used, the consumption averaging about 25 lbs. per net ton (2,000 lbs.). This low electrode consumption for a small furnace of the 3-phase type probably is due to the fact that shortly after the furnace went into operation, the solid copper-type electrode holders were abandoned, and low-carbon steel holders substituted. Each holder has two hinges, and the bus-bars are continued on out past each hinge, to prevent any heating at this point. The advantages of this holder include the absence of any water-cooling, and freedom from breakage due to torsional stresses. The ease with which an electrode can be slipped also is a decided advantage.

The operation of the furnace for the past year has been on a 24-hour schedule, and while lack of transformer capacity was a serious handicap to maximum production, the furnace made an average of six to seven heats in 24 hours. A 1-ton furnace built to-day would have more transformer capacity, and with, say, 450 k.v.a. as many heats could undoubtedly be made in 12 hours, at the same time effecting economy in power consumption.

Actually, the power consumption has averaged 950 kw.-hours per net ton of steel in the ladle, which is about what might be expected of a 1-ton furnace with insufficient power to run it. Even in the short length of time in which the 2-ton furnace has been in operation, it has been demonstrated satisfactorily that steel can be put into the ladle at the same temperature for the same purpose, with a kw.-hour consumption not exceeding 750 per net ton (2,000 lbs.), and undoubtedly the power consumption on 3-ton and 6-ton furnaces is considerably less than this. Every effort is made to minimise the length of time between heats, and it not infrequently happens that bottom is made, and the charge is in the furnace, and the current on by the time the previous heat is poured, a matter of some eight or ten minutes.

To be able to introduce into a furnace a given amount of manganese, silicon, chrome, vanadium, etc., and hold it in the metal for an indefinite period, theoretically getting in the steel just what was introduced, is proof of the almost perfect deoxidising possibilites of the electric furnace and of the condition of the steel as it comes from the furnace, the advantages of which must be apparent to operators of converter and open-hearth, who are obliged to finish their metal in the ladle, resulting in an inferior product.

Were the whole heat to be put into a big ladle, and bottom-poured direct into the moulds, there would be no necessity for the use of any aluminium, but as the practice necessitates the pouring of the metal from the furnace into a big ladle, and again pouring it into shanks, and from the shanks into the moulds, it must be plain that this practice is very severe on the metal. No matter how thoroughly the steel might be deoxidised in the furnace, the tendency of the metal when it is handled so many times, and at a temperature sufficiently high to pour very light work, is to absorb some oxygen, and a small addition of aluminium is made in each shank as a preventive rather than a cure. There have been periods, however, when no aluminium was added even in the shanks, for weeks at a time, but this practice taxes the skill of the melters to the utmost, and is not to be recommended when shanking steel in small quantities at high temperatures.

The finishing of a heat in the electric furnace requires very nice judgment on the part of the operator, and as the process is comparatively a new one, a scarcity of experienced melters is probably often the cause of much steel being put out in the market as "electric steel" which is not worthy of the name.

Too much cannot be said of the physical properties of electric steel, when properly made. With a view of ascertaining what electric steel would pull in comparison with steel from the converter and open-hearth, some 20 test bars were taken from as many consecutive heats. Their average analysis was as follows:—Carbon, 0.23 per cent.; silicon, 0.29 per cent.; manganese, 0.62 per cent.; phosphorus, 0.018 per cent.; sulphur, 0.028 per cent. The physical properties were as follows:—Ultimate tensile strength, 71,417 lbs. per sq. in.; elastic limit, 43,417 lbs. per sq. in.; elongation, 31.60 per cent. in 2 in.; reduction of area, 51.00 per cent.

It will be noted that the average elastic ratio was 61 per cent. of the ultimate tensile strength. The only heat treatment that the test bars received was a slow anneal at about 1,600 deg. F. Of the same analysis and with the same simple heat treatment, no tests from the converter or open-hearth have come to the author's attention approaching these figures.

The Filtration of Air.

Purified air, in addition to having a beneficial effect on the health of the occupants of buildings, possesses several other advantages that are not so generally recognised. Buildings equipped with mechanical ventilating plants are usually situated in cities or industrial centres where the atmosphere contains much dirt, dust, soot, and other foreign matter, which, owing to the numerous air changes, is drawn into the building in larger quantities than in the case of natural ventilation. Filtered air has a real commercial value in many branches of the industrial world, and there are many ways in which it is profitably employed. One of the most important applications is for cooling turbo-generators. These machines are small in size in proportion to their output, and have consequently a limited space, wherein only comparatively small air channels can be embodied for the dispersion of the heat. Since the introduction of mechanically-ventilated generators, it has been found that the use of unfiltered air has a deteriorating effect on the insulation, owing to the presence of dirt and dust particles in the atmosphere, which are gradually deposited on the windings, causing local overheating, and eventual breakdown of the insulation. The hammering action also of many thousands of minute dust particles impinging on the end windings wears away the varnish and insulation fabric, with the result that when the machine in such a condition cools down in an atmosphere of ordinary humidity, the end windings rapidly absorb moisture, causing serious and unexpected "burn-outs." The importance of filtration is still more evident when the amount of air required for ventilating large turbo-generators is taken into account. For instance, a moderately large generator would use 20,000 cub. ft. of air per minute, which means a total of 28,800,000 cub. ft. per day of 24 hours. As a rough approximation, it may be assumed that one hundred-millionth of the volume of the air in the vicinity of power plants consists of dust, dirt, and other foreign particles. This would mean that 87 cub. ft. of dust would be blown into the machine during a year of 300 working days. While, of course, a part of this dirt will pass directly through the machine, a portion will be deposited in the air passages, due to the air swirls and eddies. Such deposits of dirt become a considerable handicap to ventilation, as the quantity of air is decreased, due to partial closing of the ventilating passages, and the cooling effect of the air greatly diminished owing to the fact that the air cannot come directly in contact with the heat-radiating surfaces.

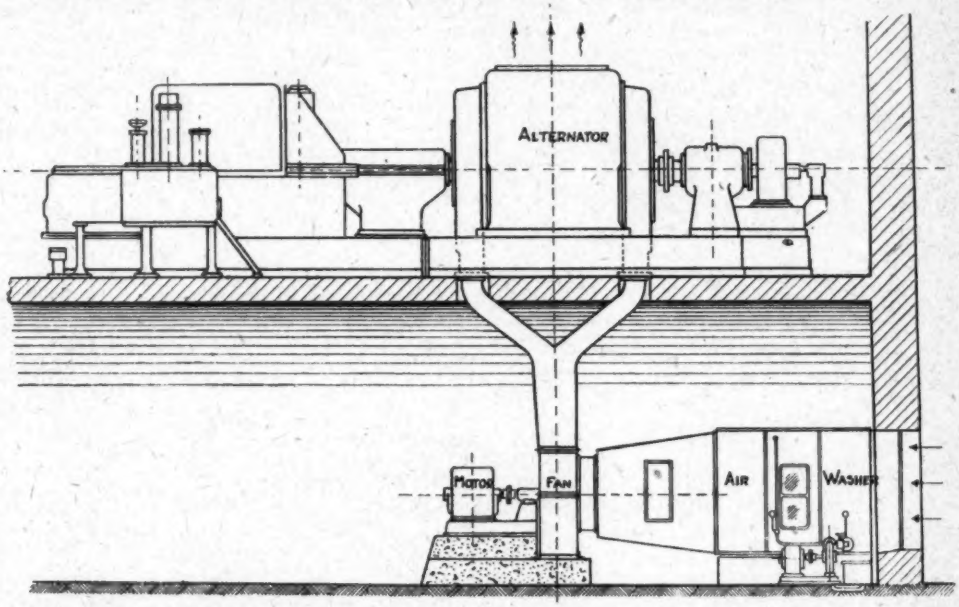


FIG. 1.—ARRANGEMENT OF "SIROCCO" AIR WASHER AND FAN INSTALLED IN BASEMENT BETWEEN FOUNDATION ARCHES. AIR SUPPLY DRAWN FROM OUTSIDE ATMOSPHERE AND DISCHARGED INTO ALTERNATOR THROUGH A BREECHES PIPE.

The above advantages of filtered air apply also in the case of forced or pipe ventilated motors working in a dusty atmosphere. However well they may be protected, the presence of grit and dust in the atmosphere has a destructive effect, not only on the windings but also on the bearings. By using purified air the dusty atmosphere does not enter into the motor, thereby prolonging its life and allowing it to operate under ideal conditions irrespective of its surroundings.

Filtered air is also valuable in the case of air compressors, as the admission of gritty and dusty air is deleterious in its effects on the valves and cylinders, causing trouble and expense, and resulting sometimes in a breakdown. Particularly is this the case when the compressor is installed at a colliery, where the atmosphere often contains a certain proportion of coal dust.

The types of air filters generally in use may be broadly divided into two classes—dry and wet.

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The former may consist of cloth-of-fibre screens, while in the wet-type filters the purification is obtained by means of Nature's own cleansing method, namely, by passing the air current through a fine water spray. The dry filter takes up more space

FIG. 2.—SCRUBBER AND ELIMINATOR PLATES.

than a wet one, and, where cloth screens are used, there is also the risk of fire due to spontaneous combustion. Further, in the dry type the maximum quantity of air passes through when the filter is clean, gradually lessening as the cloth becomes choked up, thereby setting up more resistance to the free flow of the air. These filters also require to be cleaned frequently, which can usually only be accomplished when the machine is out of action.

In the wet type of filter, as just explained, the air is washed by passing it through a chamber filled with a very fine mist, which causes the bulk of the solid matter suspended in the air to be precipitated down into the tank at the base of the machine. The air, after leaving the spray chamber, encounters a battery of scrubber plates, on which any dust or dirt remaining is deposited, and then passes on to a series of eliminator plates, by means of which it is buffeted from side to side, depositing during this process any free moisture upon the eliminators, and leaving the washer in a clean and cooled state, with no trace of free moisture.

Fig. 1 shows an arrangement of a "Sirocco" air washer and fan made by Messrs. Davidson & Company, Limited, of Belfast. Fig. 2 gives a view of the series of scrubber and eliminator plates in the spray chamber; while Fig. 3 shows an air washer in process of erection. In this filter the resistance to the air current is constant, thus allowing the same volume to pass all the time, and as the resistance is low, less fan power is required to pass a given volume of air than in the case of a dry filter. It is also easily cleaned while in operation. The water consumption is very low, as it is recirculated by means of a pump passing through two sets of filters, so as to prevent any dirt choking the spray nozzles. This washer will remove 98 per cent. of solid matter from an impure atmosphere, and will deliver the air without any free moisture and in a cooled state.

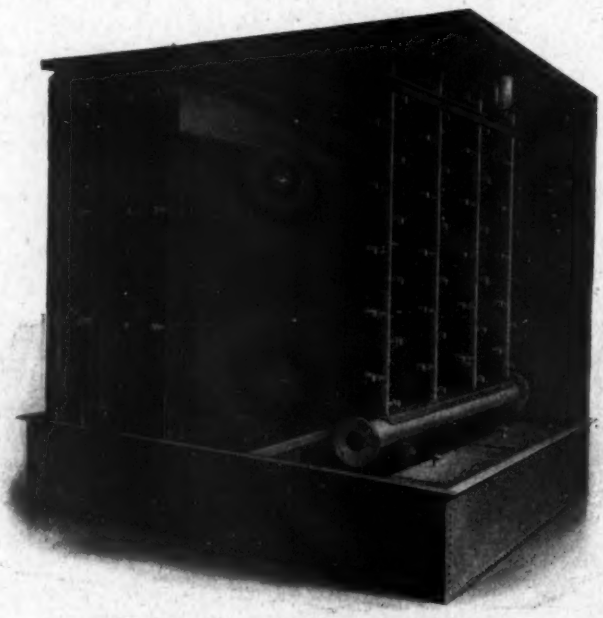

FIG. 3.—AIR WASHER, PARTIALLY ERECTED.

ELECTRIC FURNACES FOR FERRO-ALLOYS AT ROWLANDS GILL.—Mr. Henry Peile, chairman of the Newcastle Section of the Society of Chemical Industry, in his recent address stated that in the early stages of his company, the Priestman Collieries, Limited, experiments in the manufacture of ferro-silicon were carried out at Rowlands Gill in a small electric furnace. On the strength of the results of these experiments they erected larger furnaces, until now they had a 2,000-kw. furnace producing from 10 to 15 tons of ferro-silicon per day. During the last four or five years they had successfully produced 25 per cent., 50 per cent., 75 per cent., and a short time ago 95 per cent. ferro-silicon, the latter of which was of exceptional purity. They had now under consideration a scheme for the production of from 1,000 to 2,000 tons of this material per year. The next alloy they took in hand was ferro-molybdenum. They experienced considerable difficulty in making that alloy, on account of its very high melting point and the difficulty of getting rid of objectionable impurities. These difficulties had been overcome, and they were now producing an alloy of excellent quality, testing over 80 per cent. of molybdenum. At the beginning of the war it was discovered that there were practically no stocks of ferro-chrome in the country. They were asked to make that alloy, and within three or four weeks of the outbreak of war were in a position to supply their customers.

Non-Ferrous Notes.

Aluminium Alloy for Machining.—A very suitable mixture for small castings upon which a thread is to be cut, or machine work is to be done, is obtained by 82 per cent. aluminium, 15 per cent. zinc, and 3 per cent. copper. This alloy cuts freely and does not clog the tool.

Black Colour on Brass.—A black colour on brass can be obtained by the use of the following solution :—White arsenic, 2 ozs. ; potassium cyanide, 5 ozs. ; and water, 1 gallon. This is used as a hot dip without current. The work is immersed in the mixture, either suspended by wires or in a basket, the solution being contained in an enamelled tank or container.

White Castings for Motor-car Work.—A mixture which has given satisfaction for motor-car fittings, and which can be polished the same as nickel-plated work, is as follows :—Copper, 50 lbs. ; zinc, 35 lbs. ; nickel, 15 lbs. ; aluminium, 2 oz. The copper may be increased to 55 lbs., when the resulting castings are very hard and white.

Manganese in Copper-Nickel Alloys.—Manganese is largely used as a deoxidiser for the copper-nickel alloys. The best method of using it is to introduce it as manganese-copper, as that method renders the introduction of the manganese positive. Unless the pure manganese is added in the right manner, the results are uncertain, and lack uniformity. Pure manganese melts at a temperature very much higher than German-silver or other nickel alloys, and when it is added to the molten metal it does not melt, but remains on the melted mass in its original condition, being removed when the crucible is skimmed. The best method is to first make a rich copper and manganese alloy, and then use this for adding to the German-silver or other alloy to be treated. The copper and manganese alloy melts at about the temperature of the German-silver and then diffuses through the metal shortly after it melts. A method which gives satisfactory results is first to make 70 per cent. copper and 30 per cent. manganese alloy. The manganese and copper are melted together in a crucible at a heat sufficiently high to melt the manganese, after which the mass is stirred and poured into small bars that can readily be cut into pieces. The resulting cupro-manganese is added to the metal or alloy in the proportion of about 5 oz. to 100 lbs. of the molten metal. The best results are obtained if it is added when the metal is put into the crucible and it is allowed to melt with the other metals.

Rhotanium, a Substitute for Platinum.—An interesting and important alloy has been produced which is claimed to be an entirely satisfactory substitute for platinum, either for crucibles or ignition tubes, thermo-couples, etc. The new material is called rhotanium. Its composition is not revealed, but it is announced to be an alloy of metals of the platinum group. Platinum has increased in value since the war started until its present price is nearly £20 an ounce. The price of the new alloy is the same, but its actual cost is about 50 per cent. less, since its specific gravity is about half that of platinum. As to the qualities of the new substitute, it is stated that besides its relative lightness, it is perfectly satisfactory for all work where platinum has had to be used in laboratory work. It is insoluble in hot, concentrated or dilute hydrochloric, nitric or sulphuric acids, and is not affected by alkalis or sulphide solutions. It will not oxidise at any temperature, and is practically unaffected by fusion with alkali carbonates and similar fusion salts. Another important claim is that a reducing flame does not produce the crystalline effect so common to platinum. Rhotanium is very malleable and ductile, can be hammered, drawn or spun, and its colour is indistinguishable from platinum. Its tensile strength is about 20 per cent. in excess of that of platinum, and its hardness nearly twice. A thermo-couple of the new alloy is reported to develop an electromotive force nearly six times as high as that given by the platinum platinum-rhodium couple and higher than that of most base metal couples at the same temperature. The new alloy is being manufactured by the Industrial Research Corporation of Cleveland, Ohio.

Oxide in Brass and Bronze.—Discussing the inspection of bronze and brass recently before the American Institute of Metals, Mr. E. Jonson remarked that the best way to discover the presence of oxide is to make tensile tests on specimens cut from a coupon cast from the same melt. The admixture of oxide, he continued, is indicated by the greatly reduced elongation and by the low ultimate strength. The tensile tests should, therefore, be specified for all important brass and bronze castings, no matter whether a certain strength and elongation are of mechanical value or not. If this is impracticable, oxidation may be discovered by making a bending test on a machined specimen. A number of small cracks on the outside of the bend would indicate the presence of oxide. Oxidation of metal in the crucible is a very common defect, especially of the mixtures of high percentage of copper—that is, of the bronzes. When tensile or hydrostatic tests are not made the metal is generally allowed to become oxidised in the crucible, because this defect does not show on the surface of the casting. To specify bronze castings merely by the mixture is therefore useless. A bronze casting may be made of the correct mixture and may show no surface indication of defects, and still may be nothing but a honeycomb of metal, the cells of which are filled with oxide. The presence of included dross is more difficult to discover. If a hydrostatic test cannot be made, it is practically impossible to find such defects unless they happen to come to the surface of the casting, and even a hydrostatic test does not always reveal such defects. The best assurance against this kind of defects is correct moulding. The moulding of a casting should be planned while the casting is being designed. Whenever practicable, castings should be poured from the bottom. In determining the position of the casting in the mould, extensive flat upper surfaces should be avoided, as dross may accumulate by being caught under the flat surfaces of the mould or core.

Reclaiming Old Metal.—At the Hawthorne works of the Western Electric Company, Chicago, where materials to the value of nearly £300,000 are used each month, the following approximate monthly averages of scrap and waste materials are disposed of to outside concerns :—Brass, 100 tons ; copper, 180 tons ; including 125 tons from the cable, rubber, and insulating shops ; German silver, 17½ tons ; iron and steel, 89 tons ; solder skimmings, 4 tons ; and lead, 833 tons. A vast number of the parts used in the manufacture of telephone apparatus are punched from sheet iron, brass, or German silver. These scrap metals are kept separate in the shops, and are sent to the by-products department, where they are compressed into bales, weighing 1,100 lbs., by an electrically-operated press, the weight depending to a large extent upon the shape and size of the material used. The apparatus for separating the dust and dirt from the small chips and metal shavings is very simple in construction, consisting merely of a sifter oscillated by a small motor, and a magnetic separator is used for separating the iron from the brass in the sweepings. The scrap cable is first placed in gas-heated brick ovens, where it is heated until the lead sheath has been melted and the paper insulation has been burned from the wire. The molten lead is run off into a furnace, and drawn off into pivoted moulds which are mounted on a turntable, so that one man can manipulate the levers. One lever opens the gate and allows the metal to flow into one of the moulds, while the other turns the table upon which the moulds are mounted. As the filled moulds pass around they travel under running water, which cools the lead, so that the moulds can be tipped and the pigs of lead extracted. While a portion of this lead mixture can be used in the press room, much of it is too impure to meet the severe requirements demanded in cable manufacture, and is therefore sold to refining companies. The copper wire remaining in the furnace after the lead has been run off is compressed into brick form before being sold.

Trade Talk.

THE gross value of the estate of the late Mr. B. O. Clark, ironfounder, of Tettenhall, Staffs., is £83,941.

THE LEITNER ELECTRICAL COMPANY, LIMITED, of Mabury, Woking, is paying a first dividend of 3s. 4d. in the £.

A LONDON OFFICE has been established by Mr. A. E. Dunstan, metal and alloy merchant, Sheffield, at 180, Fleet Street, E.C.

LEGISLATION is to be introduced by the Canadian Government to provide for refining lead, copper, zinc, and other metals in Canada.

THE MILITARY RAILWAYS DEPARTMENT is leaving its quarters at the Hotel Cecil for the new buildings in the Embankment Gardens.

THE INVICTA ENGINEERING COMPANY, LIMITED, is being wound up voluntarily, with Mr. F. C. Harper, 27, Chancery Lane, W.C., as liquidator.

THE SHIPPING, ENGINEERING, AND MACHINERY EXHIBITION, which was postponed at the outbreak of the war, will be held at Olympia after the conclusion of hostilities.

THE ANGLO-MEXICAN PETROLEUM PRODUCTS COMPANY, LIMITED, Finsbury Court, Finsbury Pavement, London, E.C., will in future be known as the Anglo-Mexican Petroleum Company Limited.

MESSRS. F. WOODWARD AND A. F. WOOD, general engineers, 3, Newcastle Row, St. James Street, Clerkenwell, London, E.C., trading as the Aylesbury Engineering Works, have dissolved partnership.

THE estates of John Evans, metal and machinery merchant, etc., 4 and 6, Milne Street, Perth, have been sequestrated by the Sheriff of Perthshire, at Perth. A meeting of the creditors was held last month.

CLAIMS against the Mr. G. Henderson, managing director of R. B. Tennent, Limited, iron and steel manufacturers, Coatbridge, are to be lodged with McLeish & Johnston, St. Vincent Street, Glasgow.

AN Order in Council has been issued declaring that the transfer to the Minister of Labour of some powers and duties of the Board of Trade under the New Ministries and Secretaries Act, 1916, shall take effect from January 10.

MESSRS. P. W. SANSOME, A. Clegg, A. Firth, M. Harrison, and W. Diggle, general engineers and makers of munitions, Caunce Street, Blackpool, trading under the style of the Adelaide Engineering Company, have dissolved partnership.

THE firm of James Simpson and Son, engineers and implement makers, Prince Street, Peterhead, of which Mr. J. Simpson and Mr. H. F. Stephen were the sole partners, has been dissolved. The business is being continued by Mr. J. Simpson.

THE formal announcement of the award to Hadfields, Limited, of the contracts for armour-piercing fourteen and sixteen inch Navy projectiles of the total value of 3,141,000 dollars has been made by Mr. Daniels, Secretary for the American Navy.

IN view of the fact that a Department of National Service has been established, the War Cabinet has dissolved the Man-Power Distribution Board, and has transferred the powers and archives of the Board to the Director-General of National Service.

THE partnership heretofore subsisting between Messrs. G. T. Gilby and M. M. Berner, carrying on business as iron and steel merchants, at 208, Daimler House, Paradise Street, Birmingham, under the style of Lionel Morley, has been dissolved.

MESSRS. E. GOLDSCHMIDT, P. K. Speyer, P. Becker, and L. Nachmann, metal brokers and merchants, 18 and 19, Fenchurch Street, London, E.C., trading under the style of Brandeis, Goldschmidt & Company, have dissolved partnership so far as regards Mr. L. Nachmann.

THE Controller of the Foreign Trade Department has issued a new consolidating list containing the names of over two thousand persons and firms with whom persons in the United Kingdom are forbidden to trade under the Trading with the Enemy (Statutory List) Proclamation, 1916.

THE business of Mr. F. R. Archer, 5, Farringdon Road, E.C., has been amalgamated with that of Messrs. Lehmann Bros., manufacturers of dies, screwing tools, etc., Hampshire Works, Station Road, Walthamstow, N.E. and the combined businesses will in future be carried on under the title of Lehmann, Archer & Company.

THE MINISTER OF MUNITIONS announces that he has made further Order under the Munitions of War Acts, 1915 and 1916, under which 39 additional establishments have been declared controlled establishments. The total number of controlled establishments under the Munitions of War Acts, 1915 and 1916, is now 4,623.

THE business of the Comptoir Métallurgique et Industriel, Limited, 28, Victoria Street, London, S.W., has been taken over by Mr. Frederic van der Linden, managing director. Mr. F. van der Linden has increased the working capital of this business, and henceforth the name of the firm will be F. van der Linden & Company.

THE NATIONAL STEAM CAR COMPANY, LIMITED, have erected an electric furnace at Chelmsford for the manufacture of steel for the wheels and castings for their omnibuses and other transport vehicles. The company utilise a very large proportion of scrap material. The furnace has a capacity of 2 tons, and is of the "Electro Metals" type.

The Ministry of Munitions announces that an Agricultural Machinery Branch has been set up in conjunction with the Board of Agriculture and the Food Controller to deal with the control of the manufacture of agricultural machinery and implements. It is intended to class the manufacture of all such machinery and implements as munitions work.

A SCHEME for the supervision of boy-workers in the munition factories has been drawn up by the Ministry of Munitions to aid the solution of many problems which have arisen in connection with boy labour. Copies of the scheme may be obtained on application to the Ministry of Munitions (Welfare Section), 6, Whitehall Gardens, London, S.W.

NOTICE is given that the names of the undermentioned companies have been struck off the Register of Joint Stock Companies, and such companies are dissolved:—Dereham Ironworks, Limited; Green Engine Company (1913), Limited; Lester Engineering Company, Limited; Midland Screw and Steel Company, Limited; Pioneer Pump Patents (1913), Limited; Read Conveyer Company, Limited; Turbiro Engine and Pump Company, Limited.

The Minister of Munitions announces that the Metals and Materials Economy Committee, recently appointed under the chairmanship of Mr. C. W. Fielding, will "consider and suggest the action necessary to secure economies in metals and materials as regards their use in munitions of war, taking into consideration matters affecting design, methods of purchase, stocks, import, distribution and control; with powers to take such evidence as may be necessary both from the Departments of the Ministry and from manufacturers."

The announcement was made last month that arrangements have been completed for the amalgamation of the interests of two of the largest of the firms in the West of Scotland coal and iron industries, viz., David Colville & Sons, Limited, and Archibald Russell, Limited. The amalgamation is understood to take effect from January 1. Three of the directors of Messrs. Colville will join the board of Messrs. Russell, and three of Messrs. Russell's directors join Messrs. Colville's Board. Both firms are amongst the largest privately-owned firms in their particular industries in Scotland. Dalzell Steel & Iron Works, Motherwell, the principal works of David Colville & Sons, Limited, were established about 80 years ago. The firm recently acquired the Clydebridge Steel Works, Cambuslang, and also leased the Glengarnock Iron and Steel Works, and altogether employ about 14,000 workers. Archibald Russell, Limited, own large mining interests in Lanarkshire, and at Polmaise, Stirlingshire, and they employ over 4,000 men.

THE partnership heretofore subsisting between Messrs. H. W. Pritt, M. Bowley, W. G. Pritt, and P. W. Smallwood, carrying on business as iron and metal and general merchants and metal brokers, under the style of Pritt, Bowley & Company at 46, Fenchurch Street, London, E.C., has been dissolved. Messrs. H. W. Pritt, W. G. Pritt, and P. W. Smallwood, will, with Mr. E. R. Hill, carry on business under the style of Pritt & Company at 46, Fenchurch Street, E.C. All metal exchange contracts and accounts of the late firm will be carried out and settled by Mr. M. Bowley, who will carry on business in his own name at 21, Cullum Street, London, E.C.

THE APEX STEEL COMPANY, LIMITED, of Sheffield, have installed a 10-cwt. Greaves-Etchells electric furnace. This furnace has been put down with a view to testing its capabilities in a practical and commercial manner, and if expectations are justified additional similar furnaces will be installed, as it is recognised that a furnace of this size will be the most generally useful for the manufacture of high speed tool steel. When the furnace was put in action for the first time the metal was poured in about three hours from the time of charging, which may be regarded as a wholly satisfactory performance.

AN important scheme for the promotion of closer commercial and educational relations between Glasgow and Russia was inaugurated at a public meeting in Glasgow last month, convened by the Lord Provost (Sir Thomas Dunlop). It was explained that Mr. William Weir, Director of Munitions for Scotland, had endowed for five years a lectureship in Russian at Glasgow University, and that John Brown & Company, Limited, and Wm. Denny & Son had promised a sum for five years for a Russian travelling scholarship. The Lord Provost appealed for £50,000, and explained that subscriptions would be invested in the latest War Loan.

MR. R. CARRICK, of Shipley, lecturing before the Leeds Association of Engineers on January 25, urged the improvement and development of the foundry on modern lines, to enable this country to be better able to meet the keen competition that, he said, it would undoubtedly have to face after the war. While it was generally conceded that founding was the foundation of the engineering industry, yet it was surprising what a small proportion of the inventive genius engaged for generations in the evolution of labour-saving machines had been devoted to foundry machinery Only in recent years had machine-moulding developed much.

PRACTICALLY all the electrodes utilised in refining and smelting in this country have hitherto been imported from the United States, but recent installations of electric furnaces have created a greater demand. To satisfy this demand, the Electrode Company, Limited, of Sheffield, has, as already briefly announced, been established for the manufacture of carbon electrodes, and a plant is under construction which it is expected will be in operation within the next three months. The promoters are four firms, who have installed, or have in process of erection, 23 electric furnaces, with a total capacity of 90½ tons. The new company will have an estimated output of from 3,000 to 5,000 tons per annum.

A NEW regulation under the Defence of the Realm Act deals with attempts to obtain the discharge of men from the naval and military forces and the offer of employment to them during the war. The new clause reads :—If any person, without the consent of the Admiralty or Army Council respectively, communicates either directly or indirectly with any member of his Majesty's naval or military forces or with the commanding or other officer of such member with intent to induce or assist such member to obtain or apply for his release, transfer to the reserve, or discharge, so that he may during the continuance of the war engage in civil employment, he shall be guilty of a summary offence against these regulations. Any communication with a member of any of his Majesty's forces or an officer of such member stating that if such member is released, transferred to the reserve, or discharged, employment can or may be found for him, shall be deemed to have been made with the said intent unless the contrary is proved.

A MEETING of the brass trade of Birmingham and district, convened by the Brassmasters' Association, was held on January 11, to discuss the question of the Government control of metals. Mr. James Booth (president of the association) presided, and there was a large attendance. The following resolution was passed :—"That this meeting of brassfounders of Birmingham and district, comprising manufacturers or representatives, earnestly request the Ministry of Munitions to grant permission to continue the use of commercial scrap brass, or such brass as may be unfit for munitions, in their foundries and workshops. This, while not interfering with the manufacture of Government work, will enable them to give restricted supplies of essential articles to their home customers and to retain a proportion of the foreign trade of the country, which is of the utmost national importance." It was stated that the association had already made suggestions of a similar character at an interview with the Minister of Munitions in London, but no definite reply had been received.

MR. CHARLES COLES, principal of the Cardiff Technical College, has submitted to the Technical Instruction Committee, a scheme for the co-ordination of the teaching of technology. The scheme outlined included a marine technical school, day engineering department, department of chemistry and applied chemistry department of physics, department of building trades and sanitary science, school of architecture and civic design, higher commercial school, etc. Having dealt with the question of the establishment of a separate University for South Wales and Monmouthshire, linked up with the technical colleges at Cardiff, Swansea, and Newport, and the schools of mines at Treforest and Crumlin, Principal Coles recommended that the evidence on behalf of the Cardiff Technical Instruction Committee before the Royal Commission on University Education in Wales should have regard to the recognition by the University of such departments of University character in technology and commerce as the Cardiff Technical Instruction Committee might eventually establish.

THE Cutlers' Company propose to take action with regard to the false marking of cutlery made in Sheffield. An appeal is being issued to manufacturers generally to assist in dealing with the situation which, if allowed to continue, will result in grave injury to the reputation of the city for cutlery. The appeal, which is signed by the Master Cutler (Mr. W. H. Ellis) and the late Colonel Herbert Hughes, refers to the efforts made in the past in repressing false marking, and points out that all this trouble and expense will have been in vain "if the name of Sheffield is to be dragged through the mire in another direction." The Sheffield Cutlery Manufacturers' Association have condemned the practice, and concluding their appeal, the Cutlers' Company say :—"The Company, therefore, feel that apart from their bounden duty to regulate the use of marks in the cutlery trade, and to preserve in it that 'good faith' so much identified with their body, they are supported in the issue of this warning by the trade, and they desire to appeal to every manufacturer to remember that something is due from him to Sheffield, and, therefore, it is the duty of all to try to uphold the good name of the city."

THE substitution of the following Regulation relating to employees for Regulation 41 A is announced : —Every person who employs male persons between the ages of 18 and 41 shall prepare three statements :—(1) Of all males between 18 and 41 for the time being employed who have been so employed for one week or more. (2) Of persons of either sex employed and not required to be included in (1). (3) Of all males between 18 and 41 employed during the preceding month for less than one week. Each statement shall be revised to maintain accuracy. Statements (1) and (2)

shall be kept constantly posted conspicuously on the premises. A true copy shall be delivered to the recruiting officer for the locality, and thereafter a written report during the first week in each calendar month, the written report showing any alterations. Provisions are also made with respect to exemptions. It shall be the duty of every employee to furnish to his employer such correct information as may be necessary to enable the employer to perform his obligations under this regulation, or to comply with any condition entitling him to exemption therefrom, failing which he shall be guilty of a summary offence.

An inquest was held at Lambeth last month on the bodies of the two men who met with their deaths at the explosion at a South London metal refinery. The evidence of the works manager showed that the men were charging a furnace with scrap lead when the explosion occurred. On running across to the furnace he found there was a yellow smoke enveloping the whole shop, which left a bitter taste in his mouth. On examination he found the lead was covered with a yellow powder, which he took to be yellow ochre. The powder had been sent to an assayer, but owing to the holidays they had not yet had a report. Further evidence was given to the effect that the lead had originally been bought from a contractor engaged at a munitions works in Kent. A letter from the Ministry, dated December 21, stated that an accident had taken place owing to carelessness in melting scrap lead, and asking the purchaser to exercise great care with lead obtained from the works. The purchaser was warned that the lead must not be brought into contact with any heat until the pipes had been washed, and he could only sell it on similar terms. A representative of the Ministry of Munitions produced a letter which had been sent to all munition works, stating that in the disposal of scrap material, to avoid danger, warning should be given to dealers. Any metal covered with a yellow powder must be washed before putting into a fire, and iron pipes containing anything explosive must not be sold as scrap. The letter advocated the boiling in water of the metals, and in cases where factories could not do the boiling themselves the purchasers must be warned of that necessity. The Chief Inspector of Explosives expressed the opinion that the explosion would be accounted for by one of the lead pipes containing a certain quantity of picric acid. In small quantities the acid merely burned, but lead picric was far more dangerous. He expressed the opinion that these metals should be treated at the munition works before being sold to get rid of anything that might be dangerous to life. Personal persuasion on dealers ought not to come in. The jury returned a verdict that the men died of shock caused by the explosion, and that death was due to negligence on the part of the Ministry of Munitions, but such negligence was not criminal. A rider was added that immediate steps should be taken to guard against similar accidents in the future.

Official Price of Aluminium.

The selling price of aluminium ingots of ordinary commercial purity of 98/99 per cent. has been fixed by the Ministry of Munitions at £225 per ton, carriage paid to consumers' works.

The maximum selling price of remelted aluminium scrap and swarf ingots of 98/99 per cent. purity has been fixed at £210 per ton, carriage paid to consumers' works. The maximum price must not be exceeded, but a lower one may be fixed by agreement between the seller and the buyer, based upon the metallic aluminium content.

These prices are to take effect as from January 1, 1917, and permits under Regulation 30A of the Defence of the Realm Regulations will be granted only for such dealings in the above-mentioned materials as are in accordance with the above prices.

The above prices are subject to alteration, at any time, as may be directed by the Minister of Munitions.

Personal.

The late Sir Hiram Maxim has left estate of the gross value of £33,090.

The late Mr. Thomas Baird, iron merchant, of Glasgow, left estate valued at £5,701 gross.

Mr. D. J. Shackleton, C.B., has been appointed Permanent Secretary to the Ministry of Labour.

The late Mr. John Williamson, J.P., engineer, of Cannock, left estate of the value of £24,469 gross.

Mr. John Mann has been appointed Assistant Financial Secretary to the Ministry of Munitions.

The Ministry of Labour has appointed Mr. H. B. Butler, of the Home Office, to be Assistant Secretary to the Ministry.

Mr. Neville Chamberlain has appointed Mr. Arthur Collins to be general secretary of the National Service Department.

The late Mr. T. Slingsby, a director of Walter Slingsby & Company, Limited, malleable ironfounders, Keighley, left estate valued at £19,235.

The late Mr. Thomas Peat, ironfounder, of Bank Street, Farnworth, near Bolton, left estate valued at £2,656 7s. 6d., with net personalty £494 8s. 9d.

The late Sir William Theodore Doxford, chairman of William Doxford & Sons, Limited, left estate of the gross value of £151,110, and net personalty amounting to £143,532.

Mr. John H. Bunting, who for the last four years has been joint manager of Bruce Peebles & Company, Limited, Edinburgh, has been appointed general manager of the company.

Captain Laverack, who has been wounded and has received the Military Cross, is an electrical engineer, formerly at Messrs. Belliss & Morcom's works at Birmingham and afterwards with Messrs. Siemens Bros.

Mr. G. Mure Ritchie, chairman of the Barrow Hematite Steel Company, Limited, and of the Millom & Askam Hematite Iron Company, Limited, has been elected a director of the Furness Railway Company.

Mr. J. B. Hamilton, of Leeds, has been appointed to the post of Director of Trades Regulations in the department of the Admiralty, which is being formed by Mr. Lynden Macassey, K.C., for the purpose of organising shipbuilding and engineering labour.

Mr. F. Lewins, who has just retired from the position of works manager of the North-Eastern Marine Engineering Company, Limited, has been the recipient of a presentation from the officials and men. Mr. Lewins has been in the company's service for thirty-three years.

Capt. M. Kitchen, R.F.A., of Leeds and Harrogate, who is mentioned in despatches, has held a commission in the Territorial Artillery for several years. He is a son of the late Mr. Frederick Conyers Kitchen, and a partner in the engineering firm of Messrs. John King & Company, of Leeds.

In the New Year's list of appointments to the D.S.O. we note the name of Lt.-Col. W. F. Cheesewright, R.E. Lt.-Col. Cheesewright will be well known to our readers as one of the directors of Eagland & Company, Limited, proprietors of the "Iron and Coal Trades Review" and the "Foundry Trade Journal."

Mr. R. Tinn and Mr. D Low have been elected directors of the Gocle Shipbuilding and Repairing Company, Limited, and the Dundee Shipbuilding Company, Limited. Mr. Tinn joined the company at its inception, and has for several years occupied the position of manager, while Mr. Low has been manager of the allied company, the Dundee Shipbuilding Company, Limited, since its commencement.

Alderman George Gummer, J.P., head of the firm of G. & W. G. Gummer, brassfounders, Rotherham, has declined an invitation to become the Liberal candidate for the Rotherham Parliamentary Division, which seat has been rendered vacant by the elevation of Mr. J. A. Pease to the peerage. Mr. Gummer is senior alderman of the Rotherham Corporation, and president of the Northern Brassfounders' Association.

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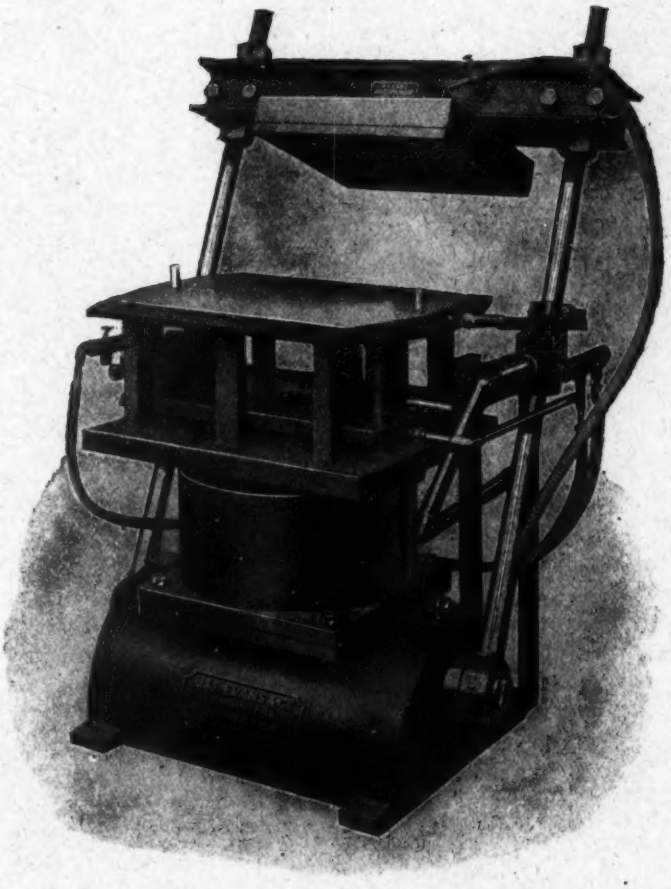
Pneumatic, Hydraulic, Jar Ramming, & Hand Power.



JAMES EVANS & CO., BRITANNIA WORKS,

BLACKFRIARS, **MANCHESTER.**

Deaths.

MR. C. H. CLAYDEN, chief superintendent-engineer of Furness, Withy & Company, Limited, died recently, aged 37 years.

THE death is reported from Paris, at the early age of 49 years, of M. Louis Janin, the founder of the Forges et Lamineries de Creil.

MR. ADAM EASTON KNOX, of the firm of Adam Knox and Sons, engineers, Crownpoint Road, Glasgow, died on January 22, aged 62 years.

MR. R. W. MURRAY, chairman of the Avonside Engine Company, Limited, Fishponds, Bristol, died suddenly at Falmouth, on January 2.

MR. A. J. IRELAND, who for many years was on the staff of the British Thomson-Houston Company, of Rugby, died recently at the age of 57 years.

LIEUT. Y. ANNAND, of the Highland Light Infantry, youngest son of Mr. R. C. Annan, managing director of the Northern Press & Engineering Company, South Shields, has been killed in action.

THE death took place on the 8th ult. of Mr. George Kelly, of the Boghead Engineering Works, Denny. The deceased, who was a native of Denny, was 73 years of age.

MR. J. BROWN, Ivy Lodge, Victoria Road, Kirkcaldy, died last month. He was for many years the active head of Brown's Engineering Works, in Cowan Street and Market Street, Kirkcaldy. The deceased was 84 years of age.

THE death has occurred at Beckenham of Mr. S. B. Halcomb, of Lydgate Hall, Sheffield, a director of the firm of Sanderson Brothers & Newbould, Limited, of Sheffield. Mr. Halcomb, who had been ailing for five or six weeks, was 52 years of age.

CAPT. JAMES HAMILTON, Scottish Rifles, attached R.E., who was killed in action, was the son of Mr. James Hamilton, manager of the Carnbroe Ironworks, Coatbridge, and was formerly employed in the Glasgow office of Wm. Dixon, Limited.

THE death took place last month, at his residence in Clydebank, of Mr. John Gow Stevenson, manager of the shipbuilding department of John Brown & Company, Limited. The deceased, who had been in ill-health for some months, was 44 years of age.

THE death is announced from France, at the age of 76 years, of M. Claudius Magnin, vice-president of the directorate of the Compagnie des Forges et Acieries de la Marine et d'Homecourt. The deceased, who was well-known in French metallurgical circles, had been associated with the company for nearly fifty years.

THE death took place at Trindle Villa, Dudley, recently, of Mr. S. Meredith, at the age of 78 years. The deceased gentleman was in the employ of Messrs. J. & C. Holcroft, of Dudley Port, as furnace-builder, for upwards of fifty years, and retired from business about five years ago. He was a member of the Staffordshire Iron and Steel Institute for many years.

THE death took place on January 6 at The Westlands, Compton Road, Wolverhampton, of Mr. William Evans, senior director of Joseph Evans and Sons (Wolverhampton) Limited, Culwell Engineering Works, Heath Town, Wolverhampton. The deceased gentleman, who was 70 years of age, had been in failing health for some time. He was a generous contributor to charitable objects.

THE death has occurred at Seaham Harbour, at the advanced age of 91 years, of Mr. George Hardy, formerly manager for many years of the Londonderry (Seaham and Dunderland) Railway, and the Londonderry Engine Works. A native of South Shields, Mr. Hardy served his time with Messrs. Marshall, engineers, at that town, and before going to Seaham was in the employ of Lord (then Sir William) Armstrong, of the Elswick Works.

THE death took place at his residence at Swansea last month of Mr. William Jones, metal merchant, at the age of 64. The deceased was a native of Carmarthen, and went to Swansea when young, entering the employ of Boulton's Engineering Works, where he became cashier. Subsequently he was cashier at the Central Dry Docks, Swansea, and the Bute Dry Docks, Cardiff, but about twenty years ago established himself in business as a metal merchant at Swansea.

THE death occurred in London, recently, at the age of sixty-six, of Mr. Edward Martin Goodman, who was a partner in the firm of Scholefield, Goodmain, & Sons, Birmingham, until it was converted into a limited liability company in 1913. He also became associated with other commercial concerns, and was a director of the Birmingham Small Arms Company for many years until the amalgamation with the Daimler Company took place. Afterwards he became chairman of the Birmingham Metal and Munition Company, of which he had been a director from its formation, and held that appointment until three years ago. He was also interested in the management of Messrs. Elkington & Company. Some time ago he retired from business, and since then had resided at Uplands, Ledbury.

THE death took place at his residence, Kerschill, Falkirk, last month of Lieut.-Col. A. M. Kennard, D.S.O., D.L., whose health had been undermined by active service in the present war. Born on July 7, 1867, the deceased officer was a son of the late Mr. Arthur C. Kennard, of the Falkirk Iron Company. He was educated at Eton, and, adopting the Army as a profession, served in India, Gibraltar, and South Africa. He retired from the service with the rank of major in 1903, but on the outbreak of the present war again rejoined. He was wounded at the battle of Loos in September, 1915, and again on the Western front in September last. Lieut.-Col. Kennard was a director of the Falkirk Iron Company, Limited, and a Deputy-Lieutenant and Justice of the Peace for Stirlingshire.

WE regret to announce the death of Mr. Henry Davis, governing director of John Davis & Son (Derby), Limited, All Saints' Works, Derby, which occurred last month at his residence, Castle Hill House, Duffield. At the time of his death he was chairman of the National Shell Factory, and it was greatly due to the extra strain of this work which caused his untimely decease. Mr. Davis, who was in his 64th year, was the son of the late Mr. John Davis, who established himself in business in Derby about 1830, and founded the now well-known firm of John Davis & Son (Derby), Limited. He had several sons, some of whom are established in business in America and elsewhere. One of them, Mr. Henry Davis, remained with his father, ultimately becoming head of the firm, which, under his skilful direction, has assumed a position of very high standing as manufacturers of mining instruments, many of which are the firm's own patents.

THE death of Colonel Herbert Hughes, C.B., C.M.G., which occurred with tragic suddenness last month, whilst he was engaged in business in London, removes one of Sheffield's foremost and most active public men. Colonel Hughes, who was the son of an Oxford Alderman, went to Sheffield in the late eighties, and became a member of the firm of Younge, Wilson, & Company, solicitors. He later become chairman of the Sheffield Chamber of Commerce, and also of the local Munitions of War Committee, which acts as an intermediary between Sheffield munition firms and the Minister of Munitions. Taking a deep interest in higher education, he held many offices in the city, and did much to further the establishment of Sheffield University. Later in his business career he became a director of William Jessop & Sons, Limited. His other activities included Vice-Consular appointments for Sweden and the United States, he actively participated in the Volunteer and Territorial movements, and was at one time Brigadier-General of the West Riding Regiment. He sat on important Government and Trade Commissions, and on behalf of the Cutlers' Company, to which for many years he acted as law clerk, he was indefatigable in taking action in cases where the trades-marks of Sheffield firms had been infringed. Colonel Hughes was sixty-three years of age.

TRADE SIROCCO MARK

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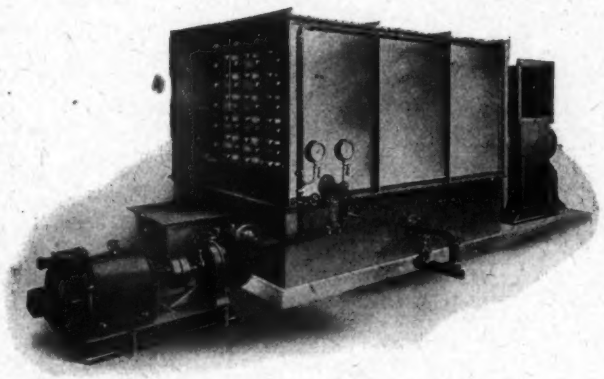

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For

Air Compressors

These Washers ensure clean valves and cylinders and the elimination of grit troubles and their attendant expenses.

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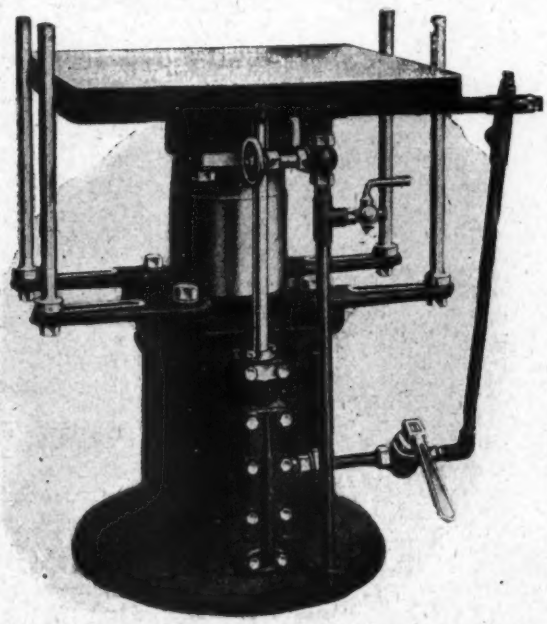

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London Agents: MURPHY, STEDMAN & CO., 180, GRAY'S INN ROAD, W.C.

New Companies.

British-Made Machine Tools, Limited.—Capital £1,000 in £1 shares.

Fylde Engineering Company, Limited. — Capital £5,000 in £1 shares.

James & Fredk. Howard, Limited.—Capital £150,000 in £1 shares (90,000 6 per cent. cumulative preference), to carry on the business of engineers, etc.

Arthur Burn & Company, Limited.—Capital £5,000 in £1 shares, to carry on the business of stampers, tool and screw makers, etc. Registered office :—55, Temple Row, Birmingham.

Clement Casting Metal Company, Limited.—Capital £1,000 in £1 shares, to carry on the business of manufacturers and founders of copper, copper alloy, etc. Registered office : 14, New Street, Birmingham.

F. W. Ratcliff & Company, Limited.—Capital £40,000 in £1 shares, to take over the business of ironmasters carried on by F. W. Ratcliff and G. H. Pearson, at Oldbury, Staffs., as F. W. Ratcliff & Company.

Milner & Company, Limited.—Capital £3,000 in £1 shares, to carry on the business of iron, steel, coal, and coke merchants, etc. F. L. Jordan is the first director. Registered office :—Town Wharf, Walsall Street, Wolverhampton.

T. P. Pollitt & Company, Limited.—Capital £1,000 in £1 shares, to take over the business of electrical, mechanical and general engineers, etc., carried on at Fish Dock Road, Grimsby, as Pollitt & Company. Registered office : Fish Dock Road, Grimsby.

Richard W. Lewis & Sons, Limited.—Capital £20,000 in £1 shares, to carry on the business of engineers, boilermakers, etc. The first directors are R. W. Lewis, J. W. Lewis, E. W. Lewis, A. Lewis, R. W. Lewis, jun., H. Lewis, W. W. Lewis, and K. L. Lewis.

Colman & Company (Birmingham), Limited.—Capital £500 in £1 shares, to take over the business of engineers, machinists, and manufacturers of and dealers in shell parts carried on at 259, Soho Road, Handsworth, Birmingham, by W. H. Colman and W. H. Smith as Colman & Company.

Geo. T. Grey & Company, Limited.—Capital £10,500 in £1 shares, to acquire from the executors of G. T. Grey, the engine-building and repairing business formerly carried on by him at the Holborn Engineering Works, South Shields. The first directors are :—Miss J. Grey, G. T. Grey, H. H. Doog, and W. A. Smith. G. T. Grey and H. H. Doog are joint managing directors.

The Association of British Chemical Manufacturers.—The word "Limited" is omitted from the title by licence of the Board of Trade. Registered on December 28 to promote co-operation between British subjects engaged as manufacturers in the chemical or closely allied industries; to place before Government and Government officials and others, either in the British Dominions or elsewhere, the views of members of the association and others upon matters affecting the chemical industries; to develop technical organisation; to promote industrial research, industrial efficiency, and the advancement of applied industry, etc. The management is vested in a council, the first members of which are :—Dr. E. F. Armstrong, Joseph Crosfield & Sons; F. H. Carr, Nottingham, chemical manufacturer; Dr. C. Carpenter, president Society of Chemical Industry, chairman of South Metropolitan Gas Company; Dr. M. O. Forster, British Dyes, Limited; J. Gray, managing director Lever Brothers; C. A. Hill, chairman, British Drug Houses, Limited; N. N. Holden, managing director Hardman & Holden, Manchester; D. L. Howard, Howard & Sons, Ilford, chemical manufacturer; C. P. Merriam, managing director British Xylonite Company, Hale End; Sir Alfred Mond, Bart., M.P., chairman, Mond Nickel Company, Victoria Street, S.W.; Max Muspratt, chairman, United Alkali Company, Liverpool; R. G. Perry, chairman Chance & Hunt, Oldbury; Sir William Pearce, M.P., director Spencer Chapman & Messel, Limited; R. D Pullar, chairman, Pullar & Sons; A. T. Smith, managing director Castner Kellner Alkali Company, Limited; the Right Hon. J. W. Wilson, Albright & Wilson, Oldbury, chemical manufacturer; and Dr. A. Ree, president Society of Dyers and Colourists. The company is limited by guarantee, each member, the number of which is unlimited, being liable for not more than £25 in the event of winding up. There are to be "group" committees, each consisting of not less than three members, representing various sections of the industry.

Use of Magnesite.

Under date of January 9 the Minister of Munitions prohibits the use of magnesite and magnesite products for or in connection with—

(1) The construction or repair of any building (other than a furnace) or any flooring or deck, or

(2) The manufacture of any insulating or non-conducting material,

except under and in accordance with the terms of a permit granted by the Minister of Munitions. All applications in reference to this order should be addressed to the Director of Steel Production (W.J.J. 342), Armament Buildings, Whitehall Place, S.W.

Applications for Patents.

The names of communicators are printed in Italic type. A new number will be given when the Complete Specification is accepted.

Guess, G. A. Process for extracting and separating nickel and copper from converter matte, etc. 18,057. December 15.

Hall, I. Means for casting. 18,070. December 16.

Hall, I. Furnaces of the tilting type. 18,071. December 16.

Mair, W. B. Casting metals. 18,092. December 16.

Rollason, A. Refining iron. 17,825. December 12.

Stowe, C. B. Process of making basic refractories. 17,865. December 12. (United States, October 5.)

Wigley, F. S. Crucible furnaces. 17,882. December 13.

Ajax Metal Company. Induction furnaces. 18,388. December 22. (United States, January 24.)

Armstrong, Whitworth & Company, Sir W. G., and Rowden, W. C. Manufacture of steel. 18,048. December 20.

Caracristi, V. Z. Exhaust draught apparatus. 18,396. December 22.

Duckham, A. M. Melting-pots or crucibles. 18,138. December 18.

Iyer, T. A. Process for coating iron with brass. 18,329. December 21.

Miles, F. W. Furnaces for melting aluminium, etc. 18,412. December 22.

Parvy, P. V. Crucible furnace for melting metals. 18,201. December 19. (France, December 27, 1915.)

Scholey, H. Hardening or tempering metals. 18,380. December 23.

Stokes, F. W. Process of moulding metals under pressure. 18,167. December 19.

Stortes, F. W. Method of making metal, etc., castings under centrifugal pressure in revolving mould or chill. 18,127. December 18.

Bache, W. Melting and reheating furnaces. 18,475. December 27.

Boddington, H. A. Means for collecting, separating, and deflecting metal turnings, etc., applicable to lathes, etc. 18,583. December 29.

Craig, A. M. Apparatus for treating metals or their alloys. 18,622. December 29.

Dawes, J. Manufacture of annealing-pots. 18,513. December 27.

Maass, E. Zinc alloys. 18,565. December 28.

Turner, J. Foundry moulding-machines. 18,550. December 28.

Conces, V. J. Castings shaking and jolting machines. 28. January 2.

Dempster, R. & J., and Ballingall, J. M. Method of treatment and utilisation of gases supplied to furnaces of hydrogen retorts. 290. January 6.

Hall, I. and L. Melting-furnaces. 17. January 2.

Millar, A., and Martin, J. Mould-dipping machine. 3. January 2.

Weston, P. J. Coverings of crucible furnaces for melting brass, etc. 17,457. December 5.

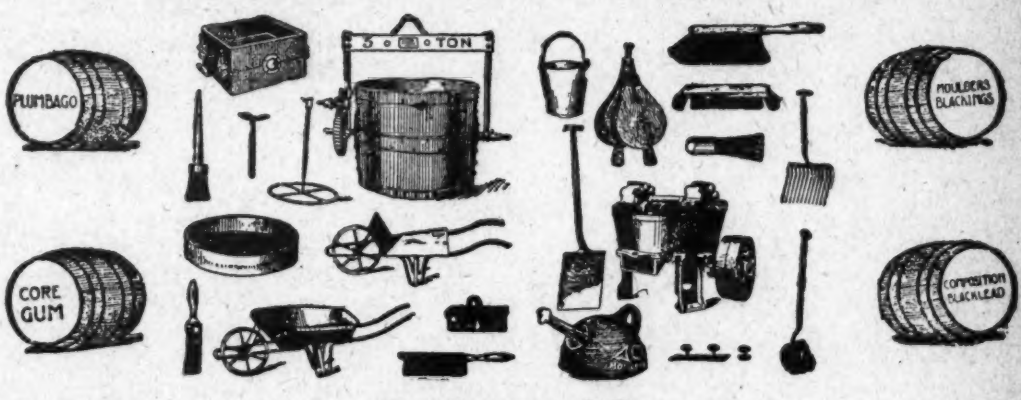
Aldridge, J. F. L. Burners for furnaces, fires, ovens, etc. 17,941. December 13.

Telegrams: "Durrans, Penistone." Telephone: 21, Penistone

Established 1863.

JAS. DURRANS & SONS,

Phœnix Works, Penistone, Near Sheffield.



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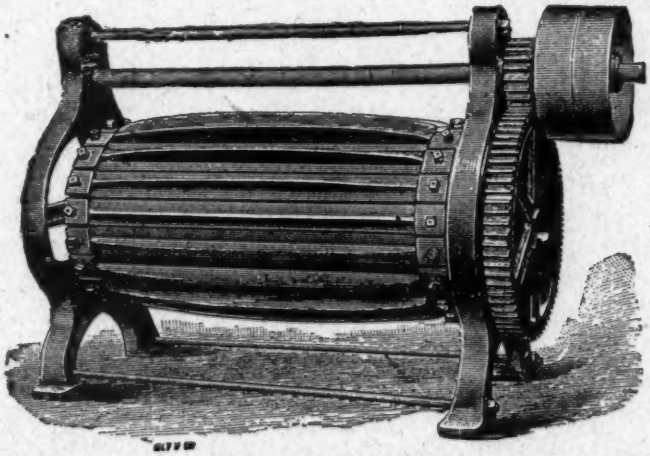
FOUNDRY EQUIPMENTS

COMPOSITION BLACK LEAD, PLUMBAGO, CORE GUM, WHITE DUST & COAL DUST

Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

Improved Foundry Rattler or Fettling Drum.



These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour.

The following testimonial explains itself :—

"Dear Sirs,—We have been using your best Blacking for a large number of years, and always use it on our large Ingot Moulds, which, as you know, we have made up to 85 tons in weight.

Yours faithfully, THE BRIGHTSIDE FOUNDRY & ENGINEERING CO., LD.

MONTHLY PRICE LIST.

The undermentioned prices, unless otherwise specified, are those obtaining at the commencement of the current month.

CONTROL PRICES.

These maximum prices of iron, steel and coke were fixed by the Government until June 30, 1916, and thereafter until further notice. Makers may sell for delivery after June 30, on the understanding that the fixed maximum prices ruling on the 1st day of any month during the period of the contract will apply to all deliveries made during that month. This intimation must not be taken to authorise any sale or purchase or other dealing prohibited under the Defence of the Realm Regulations

Pig-Iron.

	£	s.	d.
West Coast hematite, mixed Nos., 1, 2 and 3	6	7	6
Special under 0.03 P. & S... ..	6	15	6
„ „ 0.02 „	7	0	0
East Coast hematite, mixed Nos. 1, 2 and 3	6	2	6
Special under 0.04 P. & S. ..	6	7	6
Special under 0.03 P & S. ..	6	15	6
„ „ 0.02 „	7	0	0
Scotch hematite, mixed Nos. 1, 2 and 3..	6	2	6
Special under 0.03 P. & S. ..	7	10	0
Welsh hematite, mixed Nos. 1, 2 and 3	6	2	6
Special under 0.03 P. & S. ..	6	15	6
„ „ 0.02 „	7	0	0
Lincolnshire, basic or foundry ..	4	12	6
Cleveland, No. 1	4	11	6
„ other grades	4	7	6
Northamptonshire, forge	4	7	6
„ fdy. numbers	89.0		94/0
Derbyshire, forge	4	10	0
„ foundry numbers	92/6		96/6
Derby & Notts. basic.	4	17	6
Leicestershire & Notts., forge ..	4	10	0
„ „ foundry nos.	92/6		96/6
North Staffs, forge	4	15	0
„ „ foundry	4	17	6
„ „ basic	4	17	6
South Staffordshire—			
Part mine forge	4	15	0
„ foundry	4	17	6
Common Staffordshire ..	4	10	0
All mine forge	5	15	0
„ foundry	6	0	0
Warm air forge	7	5	0
„ foundry	7	15	0
Lord Dudley's silicon	8	7	6
Cold blast	9	2	6
Scotch foundry and forge—			
Nos. 3, 4, and lower grades of Monkland, Dalmellington, Eglinton, and Govan.. ..	5	14	0
Nos. 3, 4, and lower grades of all other brands	5	15	6

No. 1 quality in all cases to be 5s. per ton above these prices.

All per ton net, f.o.t. makers' works. Mers. Com. 1½%

High-Speed Tool Steel.

The maximum prices for high-speed tool steel have been fixed as follows :—

Finished bars, 14% Tung. 2s. 10d.

Finished bars, 18% Tung. 3s. 10d.

Per lb. basis. Extras as per authorised list. These prices are net delivered buyers' works.

The fixed prices for scrap which must be returned to steel makers' works are as follows :—

Millings and Turnings	5d
Bar Ends	6d

Both per lb. net delivered steel makers works.

Ferro-Alloys

Net, Delivered Sheffield steel works.

	£	s.	d.
Ferro chrome : 4/6% carbon. Basis 60%, scale 10s. per unit Per ton		—	
Ferro-chrome : 6/8% carbon. Basis 60%, scale 10s. per unit. Per ton		—	
Ferro-chrome : 8/10% carbon. Basis 60% scale, 10s. per unit Per ton		—	
Ferro-chrome : Specially refined, guaranteed maximum 2% carbon broken to small pieces for use in best quality crucible steels. Basis 60%, scale 32s. per unit. Per ton		—	
Ferro-vanadium : 33/40% Va., per lb. of Va. contained in the alloy		—	
Ferro-silicon : 45/50%. Basis 50%, 5s. scale per unit .. Per ton		—	
Ferro-titanium : 23/25%, per lb. carboniess..		—	
Ferro-molybdenum : 70/80% Mo. per pound of Mo. contained ..		—	
Ferro-phosphorus : 20/25%. Per ton		—	
Ferro-tungsten : 75% to 80% per lb. of metallic tungsten contained		—	
*Ferro-manganese 80%		—	
„ export		—	

* F.o.b. Liverpool.

Non-Ferrous Metals.

Copper.

	£	s.	d.	£	s.	d.
Standard, Cash	134	0	0	134	10	0
Three months	130	0	0	130	10	0
Electrolytic	143	0	0	142	0	0
Tough	—			—		
Best selected	—			—		

Tin.

Standard, Cash	199	5	0	199	10	0
„ Three months	200	10	0	200	15	0
English Ingots ..	—			203	10	0
Bars	—			—		
Refined	—			—		

Spelter.

American	—			59	15	0
Specials..	—			—		
Hard	—			—		
British	—			—		

Lead.

Soft Foreign	—			30	10	0
English	—			32	5	0

Antimony.

Regulus	—			—		

Aluminium.

Virgin Metal 98/99% per ton	—			—		

Phosphor Bronze.

INGOTS.	Per ton.
Alloy No. I. or II	—
III., IV, or V.	—
VI. or VII.	—
VIII.	—
XI.	—
Cast Strips and Ingots.. ..	—

CASTINGS.	Per lb.
I. or II.	—
III. IV. or V.	—
VI. or VII	—
VIII.	—
XI.	—
No. VII., Chill, Cast, Solid ..	—
„ Cored Bars	—

Delivery 2 Cwt. free to any town.

10 per cent. Phosphor Copper .. 35/- above price of best selected copper.

15 per cent. Phosphor Copper .. 40/- above price B.S.

Phosphor Tin (5 per cent.) .. £23 above price of English Ingots.

(Phosphor-bronze prices supplied by CHARLES CLIFFORD AND SON, LIMITED, FAZELEY STREET MILLS, BIRMINGHAM).

*Chromium (Metallic). 98/99% purity, per lb.	—		—
*Nickel. In cubes, 98/99% purity Per ton			—

Nickel Silver.

	per lb.
Ingots for raising	—
Ingots for Spoons and Forks ..	—
„ rolled to spoon size ..	—

*Tungsten Metal Powder.

96/98% purity.. per lb. ..	—

*Molybdenum Metal.

96/98% purity.. per lb. ..	—

*Cobalt Metal.

97% purity .. per lb. ..	—

Quicksilver.

75 lb. bottle	—

* Net, Delivered Sheffield Works.

Scrap Iron and Steel.

Cleveland.

	s.	d.	s.	d.
Steel scrap, heavy melting..	105	0	—	
Iron scrap cast (cupola metal)	90	0	95	0

London (f.o.b.).

Heavy steel	100	0				
Light „	55	0				
Heavy cast	85	0				

Control Prices.

Heavy Steel Melting Scrap	105	0	125	0		
Turnings and Borings	50	0				

Per ton delivered Buyers' Works.

Non-Ferrous Scrap.

London merchants quote the following prices for scrap metal, delivered London, and subject to market fluctuations :—

	A. Joseph. £	s.	d.
Hy. Electrolytic Copper Scrap ..	—		
Hy. Selected Scrap Brass ..	82	0	0
Hy. Tinned Copper Wire	—		
Best Selected Gunmetal Scrap ..	112	0	0
Re-melted Ingot Lead	34	10	0

Stocks.

Metals.

	Tons.
Copper, Europe and afloat	—
Tin, London, Holland, U.S.A. and afloat	—

Coke.

Middlesbrough.

	s.	d.	s.	d.
Gas Coke	31	0	—	

Glasgow.

Foundry Coke	—			42	6	
Furnace Coke	31	0		—		
Gas Coke	—					

London.

Welsh or Durham Foundry, d/d London Stations in truck	45	6		53	0	
Ditto, d/d Birmingham Stations	44	0		48	0	
Yorkshire, d/d London Stations, in truck	42	6		—		
Ditto, d/d Birmingham Stations	39	6		—		

CONTROL PRICES OF COKE.

	s.	d.
Durham and Northumberland blast furnace	28	0
„ foundry	30	6
South Yorkshire, West Yorkshire, Lancashire, Staffordshire and Midland Counties blast furnace	25	8
South Wales blast furnace ..	30	0
„ foundry	43	0

All per ton net. f.o.t. ovens.

SITUATIONS VACANT AND WANTED.

FOUNDRY FOREMAN.—Wanted, a competent Man, thoroughly experienced in modern methods and power moulding machines for producing large quantities of light grey iron expeditiously. Good organiser and firm manager of men. State age, experience, and wages required. Persons employed on Government work need not apply.—Apply your nearest Employment Exchange, mentioning *Foundry Trade Journal*, and No. A2681.

WANTED energetic WORKS MANAGER for Steel Foundry, South of England. No one eligible for military service will be engaged.—Write, with full particulars of experience, copies of testimonials, and salary required, to Box 862, Offices of the *Foundry Trade Journal*, 165, Strand, London, W.C.

FOUNDAY FOREMAN desires Situation; experienced in loam, dry, and green sand; machine moulding and repetition work.—Box 868, Offices of the *Foundry Trade Journal*, 165, Strand, London, W.C.

WANTED, for Birmingham District, Energetic Commercial Manager for Progressive Foundry. Must have had practical experience in LIGHT CASTINGS TRADE. Good salary paid to suitable man. When replying state experience, references, and wages required to Box 858, Offices of the *Foundry Trade Journal*. 165, Strand, London, W.C.

DAVID BROWN & SONS (HFD.), LTD., Gear Specialists, Park Works, Lockwood, Huddersfield, require the services of a thoroughly competent and progressive Iron Foundry Manager accustomed to machine moulding and to economical production. Output approximately 20 tons weekly; small repetition work to castings up to 10 tons each. Apply, in the first instance in writing, giving full particulars of qualifications and experience, stating age and salary expected. Applicants employed on war work will only be considered with the sanction of their present employers.

COREMAKER.—Charge-hand for Core Room in large aluminium foundry. Must be good organiser and disciplinarian, and experienced coremaker. Able to teach women and to get output. Good and permanent job to right man. Persons employed on Government work need not apply.—Apply Box 864, Offices of the *Foundry Trade Journal*, 165, Strand, London, W.C.

MACHINE MOULDER.—Charge-hand wanted to supervise about 12 pneumatic moulding machines in aluminium foundry. Required to take full charge of machines, reorganise department, and increase output. Excellent chance for experienced man with ideas. Persons employed on Government work need not apply.—Apply Box 866, Offices of the *Foundry Trade Journal*, 165, Strand, London, W.C.

FOR SALE AND WANTED.

FANS and BLOWERS.—Engine-driven, Roots' Blower, No. 5, 13½ in. discharge; Engine-driven Fan, 34 in. by 14½ in. discharge; Belt-driven Fan, 18 in. discharge; splendid ditto, 9 in. discharge; Belt-driven Roots' Blower, 5 in. discharge.—Whyte, John Street, Greenock.

FOR SALE.—24-in. Invincible Sand Mixer, capacity 3 tons per hour, for grinding, mixing and screening foundry sands, at lowest cost per ton.—Apply, HALL, 26, Paradise Square, Sheffield.

FOR SALE AND WANTED.—*cont.*

12 IN. Roots' Blower, by Dempster, driven direct by horizontal steam engine; 8-in. ditto, by Thwaites, with vertical engine, self-contained; low price; immediate delivery.—WILLIAMS & SONS, South Bermondsey Railway Station, London, S.E.

BLOWING FAN, by Alldays, 12 in. outlet; EXHAUST FAN, cast-iron casing, 10 in. outlet and inlet, F. and L. pulleys; BAKER'S BLOWER, 6 in. outlet; 30 in. New Belt-driven VENTILATING FAN; cheap.—Parker, Siddals, Derby.

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FOUNDRY FURNISHERS AND FOUNDRY REQUISITES

Of every description.

56, 58, 60, CHAPEL STREET, SALFORD, MANCHESTER.

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EVERY DESCRIPTION OF **MOULDERS'** PATENT WOOD, MINERAL AND **COAL DUST BLACKINGS** MANUFACTURED.

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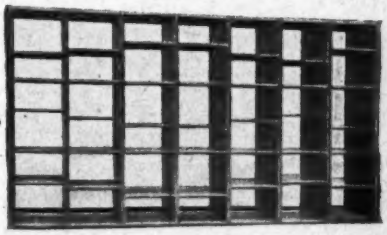

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Fireproof Steel Storage Bins

For Workshop and Warehouse.

Write for Details.

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Parting Powder.

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Largest Stock of Straw and Wood Fibre CORE ROPINGS.

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GLUTRIN—CORE GUM.

FIRE BRICKS & CLAY
CUPOLA BRICKS.
Best Quality.

LESSEES OF DELPH AND TINTERN ABBEY BLACK AND WHITE CLAY.

KING BROTHERS,
(STOURBRIDGE) Ltd.,
STOURBRIDGE.

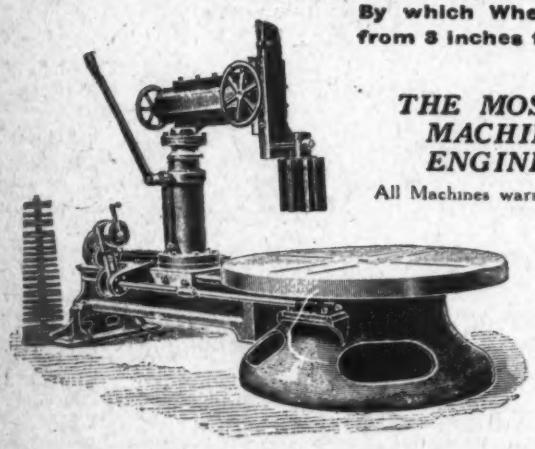
38½
McNEIL'S
PATENT UNBREAKABLE
STEEL LADLES
These Ladles are manufactured by a patented process, each from a single steel plate without weld or rivet. They are extremely light, being at the same time the strongest and most durable in the market. Ladles to contain 56 lb. of metal only weigh about 7 lb. each. They are made of all capacities from 30 lb. to 60 cwt., with or without lips: also mounted or unmounted. They are also suitable for chemical and metallurgical processes. List of sections and prices on application to
CHAS. McNEIL, LTD.
KINNING PARK IRON WORKS,
GLASGOW
36"
32½"

CAN ALSO BE MADE IN ALUMINIUM.

Kindly mention this paper when enquiring or ordering.

WHITTAKER'S IMPROVED MOULDING MACHINE

By which Wheels or Pulleys of any description or size from 3 inches to upwards of 20 ft. diameter can be made.



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All Machines warranted to Mould with the greatest accuracy and precision.

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Spur or Bevel, Straight Teeth and Double Helical Teeth Supplied to Consumers.

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SUN IRON WORKS, *OLDHAM.*

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124	Universal Machinery Corporation, Ltd.	326, Old Street, London, E.C.	Toolcraft, London	3763 London Wall.
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	Walco, Ltd.	53, Newton Street, Birmingham	Walco, Birmingham	Central 3305
168	Whittaker, W. & Sons, Ltd.	Oldham	Whittakers Engineers, Oldham	83
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Edited by I. H. Hall, Managing Director.

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2. Melts hot and exceedingly fluid and will fill every corner of your Mould.
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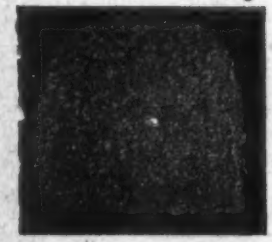
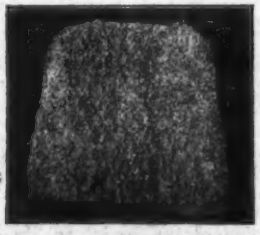
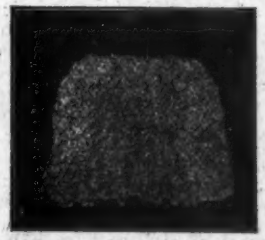

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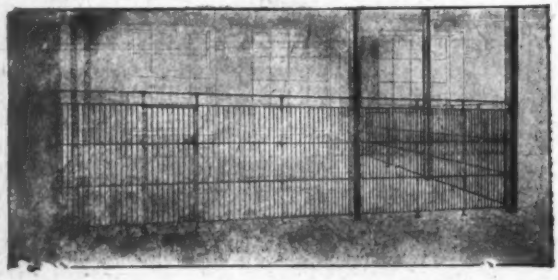

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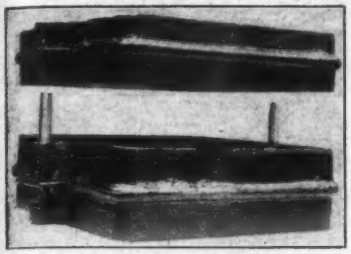

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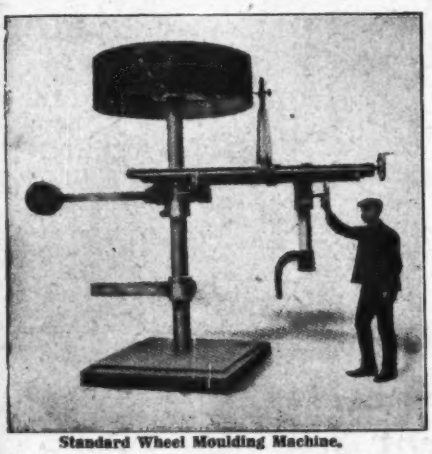

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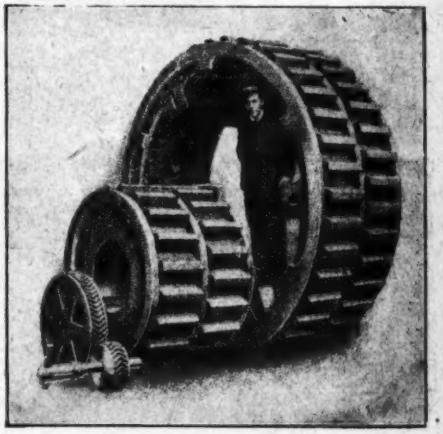

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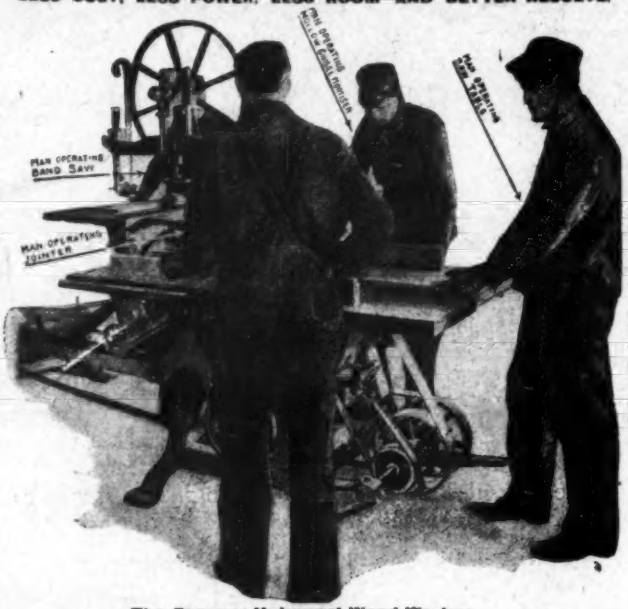

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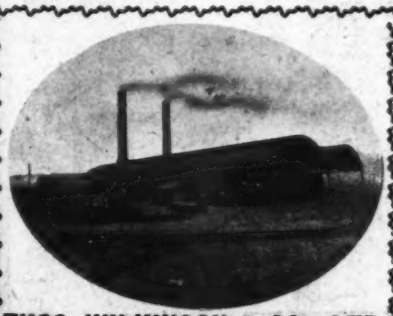

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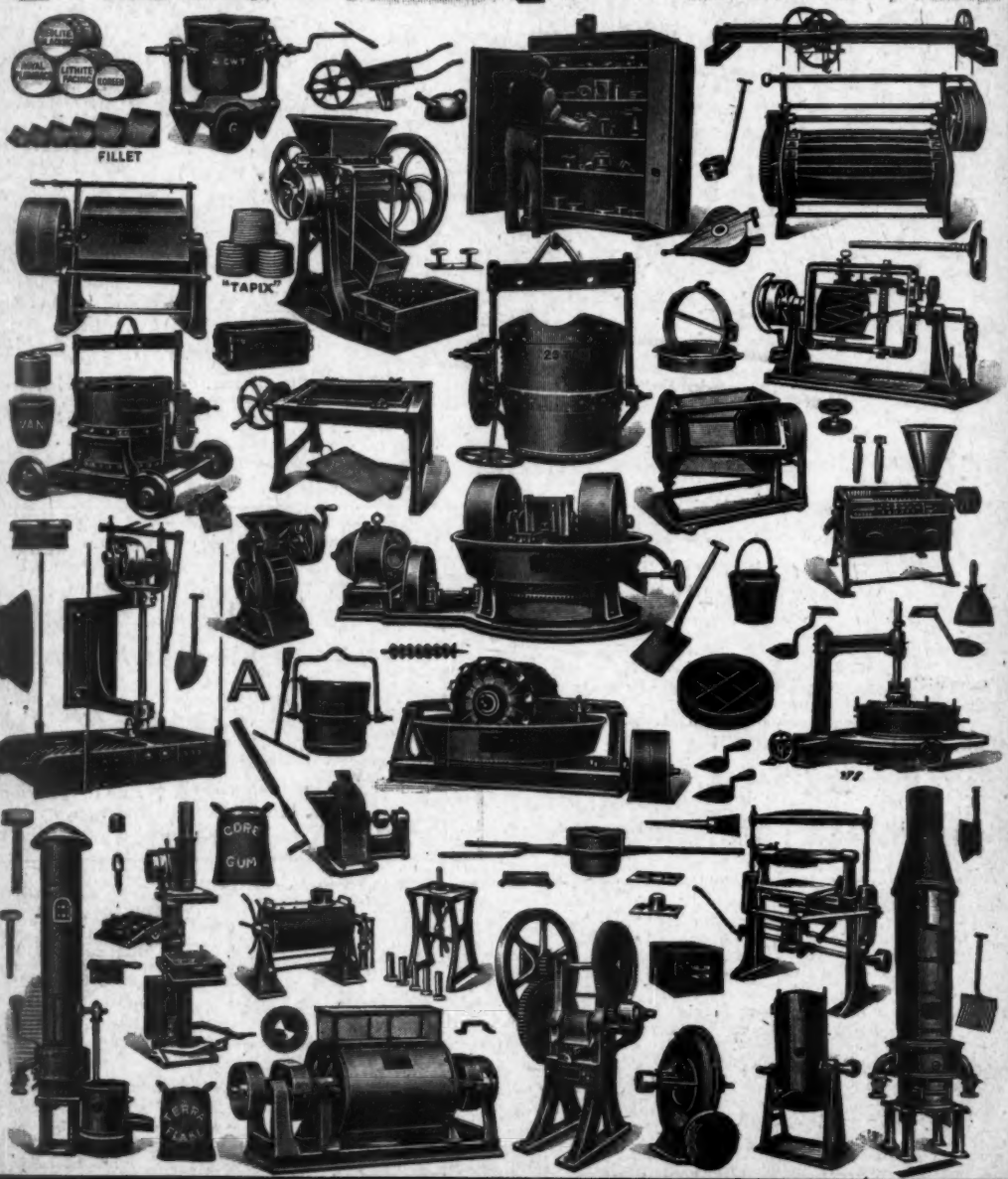

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